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The Tribune.

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PROF. HUXLEY IN AMERICA.

The stay of Prof. Thomas H. Huxley in this country has been necessarily brief. His engagement for a course of lectures before the Royal School of Mines requires his return to England by Oct. 1. But short as has been his stay with us, it has afforded several opportunities for hearing him—more, in fact, than were hoped for when the visit was first projected. It has also been of marked service to science in this country, by calling public attention to the value of our geological treasures. Soon after his arrival Prof. Huxley went to New-Haven, and there spent several days in a careful examination and study of the fossils from the West, which have been obtained by Prof. Marsh in expeditions already familiar to TRIBUNE readers. These fossils have a peculiar value. They show that in past periods animals existed whose forms were intermediate between those already known. Not only are the gaps between species thus filled, but the new forms are found in the rocks in a regular order of progression. To Prof. Huxley, a firm believer in and advocate of the theory of Evolution, these discoveries of Prof. Marsh were of the highest interest. Nothing short of his own personal examination of the specimens would probably have satisfied so careful an observer as Prof. Huxley. Having made that examination, he declares that "the reality very far exceeded his anticipation." He regards this new series of facts as establishing the theory of Evolution upon an impregnable basis. To make these facts public, and to display their importance as affording data for earth's history, were among the chief objects of his lectures in New-York.

Prof. Huxley was present during the Buffalo meeting of the American Association for the Advancement of Science, and shared in the abundant hospitality which made that a memorable occasion, being himself the most prominent figure in that assembly of scientific workers. He shortly afterward visited Niagara Falls, where he made some valuable observations which he subsequently embodied in an address delivered at Nashville. At the opening of the Johns Hopkins University at Baltimore, Prof. Huxley gave an interesting and suggestive exposition of his views respecting the management and methods of such an institution—views of value on account of his experience in educational affairs. It will be noticed that in all the speeches and addresses made by Prof. Huxley in this country and given in full in this Extra, he has made topics that relate to America a specialty.

In person Prof. Huxley is rather above the medium height; of large frame, but spare. He stoops slightly, as if habitually engaged in thought. His features are prominent and bear an expression of energy in repose. His hair and whiskers are iron gray. He speaks without manuscript or notes of any kind, and never prepares the phraseology of his addresses in advance of their delivery. His manner of speaking is quite simple and straightforward, with none of the gestures or arts of oratory. His delivery is slow and distinct, being the result of a hard and successful effort in the early part of his career to break off a previous habit of rapid speaking.

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IMPRESSIONS OF AMERICA.

PROF. HUXLEY'S SPEECH AT BUFFALO.

BRITISH NOTIONS OF THIS COUNTRY MODIFIED AFTER ARRIVAL HERE—COMPARISON BETWEEN AMERICAN AND ENGLISH WOMEN—THE WORLD'S HISTORY RECORDED IN THE ROCKS OF THIS CONTINENT.

Prof. Huxley was present at the Buffalo meeting of the American Association for the Advancement of Science. On the morning of Friday, Aug. 25, he was introduced to the Association in a few fitting remarks by the President, Prof. Wm. B. Rogers. Prof. Huxley replied as follows:

MR. PRESIDENT AND LADIES AND GENTLEMEN OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE: Permit me, in the first place, to offer you my most hearty thanks for your exceedingly cordial—I will not say unexpected—welcome, because everything I have experienced in America since my landing has been something of this kind. But I thank you for this hearty welcome. You will forgive me if my words are inadequate to express how much I feel on this occasion. I am not by nature a man of many words, and have thought the highest eloquence was in condensing what one has to say. I have been told that it would be gratifying to you to have me say something, but emotion will make my speaking a difficult task. Also, I have no scientific matter especially to communicate here; and I am quite unprepared to occupy your attention on such an occasion as this. Since my arrival in America I have discovered that the great instinct of curiosity is not altogether undeveloped among you. I experienced something of this at the time of my landing, by being interviewed by two active and intelligent representatives of your press. They were good enough to put before me in writing a series of inquiries of deepest and most profound interest, each of which would require a treatise in reply; and I am afraid I had to dismiss them with scant courtesy.

It may satisfy this curiosity if I state briefly some of my general impressions of this country. Since my arrival I have learned a great many things, more, I think, than ever before in an equal space of time in my life. In England we have always taken a lively interest in America, and have our occasional controversies with her; but I think that no Englishman who has not had the good fortune to visit this country can form a real idea of what that word America means. We have no adequate idea of the extent of your country, its enormous resources, the distances from center to center of population, and we least of all understand how identical is the great basis of character on both sides of the Atlantic. A friend of mine in England went abroad for the purpose of seeing foreign countries, and has come to America. I have been talking with him since my arrival here. He says: "I cannot find that I am abroad." I am similarly impressed. The great features of your country are all such as I am familiar with in parts of England and Scotland. Your beautiful Hudson reminds me of a Scotch lake. The marks of glaciation in your hills remind me of those in Scottish highlands.

I had heard of the degeneration of your stock from the English type. I have not perceived it. Some years ago one of your most distinguished men of letters, equally loved and admired in England and America, expressed an opinion which touched English feeling somewhat keenly—that there was a difference between your women and ours after reaching a certain age. He said our English women were "beefy." That is his word, not mine. Well, I have studied the aspect of the people that I have met here in steamboats and railway carriages, and I meet with just the same faces, the main difference as to the men being in the way of shaving. As to stature, perhaps your men have rather the best of ours. Though I should be sorry to use the word which Hawthorne did, yet in respect to the size of your fine portly women, I think the average here fully as great as on the other side. Some people talk of the injurious influence of climate. I have seen no trace of the "North American type," to which, it was said, you were reverting. You have among you the virtue which is most notable among savages, that of hospitality. I have visited your wigwams—and they are pretty good wigwams too. You entertain us with your best, and not only give us a good dinner, but are not quite happy unless we take the spoons and plates away with us.

Another feature has impressed itself upon me. I have visited some of your great universities, and meet men as well known in the old world as in the new. I find certain differences here. The English universities are the product of Government, yours of private munificence. The latter among us is almost unknown. The general notion of an Englishman when he gets rich is to found an estate and benefit his family. The general notion of an American, when fortunate, is to do something for the good of the people and from which benefits shall continue to flow. I need hardly say which I regard as the nobler of these ambitions.

It is commonly said there are no antiquities in America, and you have to come to the old world to see the past. That may be, so far as regards the trumpery 3,000 or 4,000 years of human history. But in the larger sense, referring to the times before man made his momentary appearance on the globe, America is the country to study antiquity. I confess that the reality has somewhat exceeded my expectations. It was my great good fortune to study in New-Haven the excellent collection made by my good friend, Prof. Marsh. There does not exist in Europe anything approaching it as regards extent, and the geological time it covers, and the wonderful

light it throws on the problem of evolution, which has been so ably discussed before you by Prof. Morse, and which has occupied so much attention since Darwin's great work on species. Before the gathering of such materials as those to which I have referred, evolution was more a matter of speculation and argument, though we who adhered to the doctrine had good grounds for our belief. Now things are changed, and it has become a matter of fact and history as much as the monuments of Egypt. In that collection are the facts of the succession of forms and the history of their evolution. All that now remains to be asked is how the development was effected, and that is a subordinate question. With such matters as this before my mind, you will excuse me if I cannot find thoughts appropriate to this occasion. I would that I might have offered something more worthy. I hope that your Association may do what the British Association is doing—may sow the seeds of scientific inquiry in your cities and villages, whence by a process of natural selection those minds best fitted for the task may be led to help on the work in which we are all interested. Again I thank you for your excessive courtesy, and, I may almost say, affectionate reception.

TESTIMONY OF THE ROCKS.

PROF. HUXLEY'S LECTURE AT NASHVILLE.

CHARACTER OF THE RECORDS BENEATH THE SURFACE—THEIR CERTAINTY AS COMPARED WITH HUMAN TRADITIONS — VALUE OF SCIENTIFIC KNOWLEDGE TO A COMMUNITY.

On the evening of Sept. 7 Prof. Huxley delivered a lecture at Nashville, Tenn., to a large audience. He was introduced by Dr. T. O. Summers, jr., as follows:

The appearance of the distinguished visitor before you to-night is an event of no ordinary occurrence in the annals of our city. We welcome him to our midst, and trust the magnetic influence of his person and his speech may awaken impulses which have been already kindled by the electric fire of his ready pen. No eulogium is needed from me. Upon this occasion an introduction is a grand impertinence. It is therefore to me a profound pleasure, as it is a distinguished honor, to present to you, without further remarks, the great apostle of modern science, Thomas Henry Huxley.

THE LECTURE.

Prof. Huxley said:

LADIES AND GENTLEMEN: When I left England some five weeks ago, I did so with very many determined resolutions as to the manner in which I would spend my holidays in the United States. Having just completed a season of long and laborious work of various kinds, I was more than willing to look upon this journey of mine as one in part dictated by the desire to renew family ties which had been interrupted, though unbroken, for a space of the ordinary life of a generation of men. I found, however, it would not be best for me to leave this country without addressing an audience of Americans, though it certainly did not enter into my plans to have the honor of making an appearance before the citizens of Nashville. The signal kindness and courtesy, however, with which I have been received here, would have prevailed upon me; indeed, it would have been unbecoming of me not to have met your wishes in any way that would have been practicable; and, therefore, seeing that it is your strong desire that I should address you, I have undertaken to do so this evening.

I think I made that engagement with the proviso that I had no set speech or address to make, and that all I would undertake to do would be to communicate to you such observations and such reflections as had suggested themselves to me during my unfortunately brief residence here. I find myself in what I believe is the principal city (I speak under correction) of a State the area of which is not far inferior to that of England, and which possesses within itself a variety of surfaces which is only paralleled by that which we find in England—a diversity of geological formations only to be found in the same surface of my native country—and blessed by nature with singular fertility, literally a land flowing with milk and honey, producing upon the greatest scale those cereals which, with cattle and sheep and the like, are the main support of man; a land which, in addition, possesses an unequaled mineral wealth—fields of coal which, as I understand, equal in area those of the mother country; inexhaustible resources in iron and copper and various building stones and minerals; and which, also, carries within itself all those variations of temperature, climate—perhaps a little warmer than we Englishmen are accustomed to—which are needed to create a great and wealthy population. In my visits to the institutions of your city, I have become acquainted with your admirable schools, have seen there expressions of intelligence upon the faces of the children and the young men and women who are being educated; I have seen enough of your population to convince me that, in addition to those material resources, those possibilities of wealth and well-being, there is that human element of intelligence and labor which is needed to stir such resources to sufficient development. Whether, under these circumstances, the wealth placed at your disposal is to be turned to its best account, must undoubtedly depend upon the education which you are giving your young people. My brief inspection has enabled me to say that, judging by all the standards, the education is such as to produce—I will not say produce intelligence, for one cannot do that—to cultivate the intelligence which may be pos-

sessed. I have been glad to see that an indispensable element of that education is a training in the elements of the physical sciences. I don't know how far your education is carried, but I can undertake to say this much—that while a thorough and efficient development of your resources must depend, other things being equal, on the diligence, the general activity of your population, it is also true that the development must depend upon the thoroughness and completeness of instruction in the elements of the physical sciences which is given to the masses of your population. Whether it is important to the development of your agriculture; whether it is important to the development of your mineral resources; whether it is important to the development of your mines; whether it is important for improving your means of transportation, or under whatever other aspect you choose to consider the means by which these resources can be brought to their full account, a little reflection will convince you that the development of these resources turns entirely upon the intelligent application of physical science, whether it be the practice of mechanics, chemistry or biology.

My opportunity of examining is far too slight to render it otherwise than presumptuous for me to say whether the measures you have taken are sufficient for their purpose or not. I hope you will permit me to insist upon the fact that it is only by the increase and development of the kind of education I have mentioned that these resources can be turned to a thorough and effectual account. And there is no difficulty, let me say, in the acquirement of the physical sciences in the ordinary schools. I don't speak of that matter as a theorist; I speak as having had an intimate acquaintance for the last 20 years with the educational system of the mother country. There the system by which the elements of physical science are taught in all the primary schools that have been in active operation, has scarcely acquired perfect development until now. In some branches we have 5,000, 7,000, and 12,000 or more young people under examination annually. We have organized methods of instruction. Our elementary teachers have been so instructed in the means of teaching, that at length I think it may be said that we have organized machinery by which elementary scientific teaching has been secured through the length and breadth of the land.

It is for you to say whether the same thing shall be done, whether your population will be placed in a position to enable them to take advantage of these vast material resources which are placed within your reach. No doubt such advantages as these are not to be despised; no doubt the increase in wealth and in material well-being is a great and important object to the legislator and the citizen who wishes well for his nationality; but there is another aspect under which the widespread training in the elements of the physical sciences is to be considered, and in urging upon you the importance of developing that mode of teaching in your schools, I should like to illustrate, as far as I may, this side of the question. You are aware—every one who has taught at all is aware—that a vast interest attaches in the mind of every intelligent man to the history of the past; that we all form some kind of conception of the past history of the world; and that to many of us what has taken place in the history of the world is only what has been told us. In fact, it is impossible that one's practical life should not be more or less influenced by the views which we may hold as to what has been the past history of things. Now, there are two sources from which we obtain a knowledge of the past history of things. One of them is human testimony in its various shapes—all testimony of eye-witnesses, traditional testimony from the lips of those who have been eye-witnesses, and the testimony of those who have put their impressions into writing or into print.

First, we may consider the elements obtained in that way—human historical evidence. It is upon that we depend for the greater part of our knowledge of the doings of the past. (I should like to place this subject before you as clearly as I can, but the extreme heat of this climate does not contribute to the clarification of my intellect.) I should like to state to you, in the first place, on what principles our convictions as to the validity of historical evidence depend, because there is often a broad distinction drawn between different kinds of evidence. To suppose that one kind is more valuable than the other upon grounds which are not clear—upon grounds illogically stated, and which do not bear thorough and careful inspection—always lies at the bottom of our errors in the acceptation of testimony. That which justifies us in our belief in conclusions drawn from historical evidence is, if you can sift it, but at the bottom the uniformity of nature.

For example, if I read in your history of Tennessee, "Ramsey's History," that a hundred years ago this country was peopled by wandering savages, my belief in that statement rests upon the conviction that I have that Mr. Ramsey was actuated by the same sort of motives that men are now, and that all the persons from whom Mr. Ramsey derived his information were actuated by the same sort of motives; in other words, that the men from whom he derived his information, and he himself, were, like ourselves, not inclined to make false statements, at any rate when such statements would be detected, and we might apply to them the same standards of truth and falsehood as we apply to ourselves. If you read Cæsar's Commentaries, wherever he gives an account of his battles with the Gauls, you place a certain amount of confidence in his statements. You take his testimony upon this. You feel that Cæsar would not have made those statements unless he had believed them to be true. In other words, the motives which actuated men in Cæsar's time are assumed to be the same as those which actuate men now. If it were possible to suppose that at any time the past history of the order of nature, so far as regards men, was different; if it were possible to suppose that men did not care

about the truth, or about the detection of falsehood, then you would know that their testimony could not be depended upon. So you see that a belief in testimony implies a belief in the constant order of nature.

This history of Ramsey's, of the State of Tennessee, takes you back for a very short period—not more than a hundred years or so; as far as the immediate case of Tennessee is concerned, not more than a century or so; and so far as America is concerned, not more than three hundred at the outside or thereabout. But now let us consider the other sources of information and what has taken place in a country of this kind. We find scattered about on the soil of Tennessee—indeed, I had the fortune to see specimens in your museum at the Capitol—specimens of worked flints—perhaps not true flints, but at any rate closely similar. These flints are plainly, obviously worked by the hand of man. There are also bones and tools of various kinds that are testimony as to the former population.

If the former inhabitants had died out and become lost, the discovery of these implements in the soil would, notwithstanding, be evidence of the existence of a population totally distinct from that which colonized it of late years. We might with a degree of certainty draw a conclusion from the character of these implements as to the nature of the people who were their fabricators, and the order of succession or the time of that operation could be defined by the mode of their construction. So, again, scattered over the surface of your State there are mounds wherein is exhibited the work of the so-called "Mound Builders," that has been built up by human ingenuity. They are indications of the existence of men different from those who now inhabit the land, and upon some of these mounds are found growing great trees which have taken several hundred years for their development, and it is quite clear that the "Mound Builders" had finished their work long before the time when those trees had planted themselves and grown to their present development. Now that evidence of the past history of this country is archæological. It is evidence obtained upon testimony—upon written, recorded testimony—not upon tradition, but upon material facts, which carry within themselves the evidence of their nature. And you see that this archæological evidence, as I call it, although it is much scantier—much less full than historical evidence—is incapable of false indication. I do not mean to say that ingenious people may not fabricate these stones, and I do not mean to say that people may not make mounds, but surely the fabricators would not distribute these stones over the breadth and depth of the land, nor would they employ an army of navvies to go all over this country and erect mounds. We are quite safe that they are free from human interference—from human tampering with them. And although the archæological evidence is scantier than the historical, it is the surer evidence of the two.

It might be that the different indications of those who inhabited this country before white immigration have been falsified or modified by the persons who wrote the history; but these difficulties cannot affect the conclusions we draw from such monumental evidence as that of mounds and of marked stones. If Cæsar's Commentaries had never been written, the evidence of tumuli, scattered all over Gaul, would be ample to prove the existence of an ancient race of people exceedingly different in their civilization and in their customs from the French who now cover the territory of Gaul. This archæological evidence not only has the advantage of its freedom from interferences by man, but it has the further advantage that it carries us into regions which human testimony cannot reach—which lie far beyond the utmost limit of tradition, and thus require an amount of evidence that it is almost inconceivable to suppose either oral or written testimony could furnish.

The rocky soil upon which the city stands is full of evidence of that kind. It is, as you are aware, a hard limestone. That hard limestone contains an abundance of fossils which bear more or less resemblance to animals which are living at the present day. Examine your museum and you can find any quantity of these remains. You can satisfy yourselves that they are animal remains, and the biological student can very readily convince himself that they are the remains of creatures which only inhabited the ocean at a time antecedent to the existence of the savage people whose implements are scattered over the soil, and when the ground and solid rock upon which these are scattered was a something totally different from what it is now. In fact, it was the bottom of the ocean, and on the bottom of the ocean these creatures flourished and left their remains as a monument of an era which has long since passed. So you can turn back in the history of the globe, and you will perceive that the evidence is of the simplest possible character. It is an evidence that cannot be challenged by any person of common sense who will take the trouble to look at the question. And, what is more important, it is a kind of evidence that has not been tampered with—cannot be tampered with by any sort of human interference.

I am indebted to this most admirable work—of which a copy was presented to me yesterday, a report of the "Resources of Tennessee," which, in my judgment, does infinite credit to the State which paid for it and the person who put it together—which I do not profess to have read since yesterday, yet out of which I have contrived to pick the sort of information I want of the structure of the regior where we now stand.

I find that there is a large limestone plain on part of which Nashville stands. Then there are your Cumberland highlands, away eastward. Then westward there is also a highland, some long distance west, that tips into a gulf, and on that gulf there rest other beds until you come to the valley of the Mississippi. Here we have beds which form the present foundation upon which the city stands. Upon each side you have beds of rock superposed one above the other. These (pointing to a diagram on the blackboard) being deposited upon those below. must

naturally be more recent. You may say in general terms (in any other country than America), a house is more recent than its foundation. Here I have discovered that this is not always the case, for you sometimes move your houses and put new foundations under them. Then a bed of rock which lies over another is younger—more recent than the bed of rock upon which it lies. So, when we say these beds are younger than those, we do so because these have been deposited upon the others. What do we find here? Animal remains, masses of clay, shale, limestone, stamped with the unquestionable evidence of being formed of the mud at the bottom of the ocean. You have your thick beds of coal which can be demonstrated to be the charred and altered remains of forests which grew upon the same surface when it had become dry land. You may amuse yourselves by calculating the enormous periods it took to grow these forests upon that soil and then turn them back to beds of coal. It is quite easy to see that these forests were not trees like our present trees, and the surface which we now call Tennessee was something totally different from what we now know. See how simple these calculations are. There can be no doubt that the beds of rock were formed one above another, in the order of their date—the oldest at the bottom, the newest at the top. There is not the slighest difficulty in drawing conclusions as to the conditions under which these beds of rock were formed; and in drawing all these conclusions, you make no greater assumption whatever than you make in historical evidence. That is to say, you assume that the course of nature has been generally uniform, just as your belief of ancient testimony depends upon your belief that the motives of the men in ancient times were similar to those we now see. So plants, forests, and trees did not grow in the sea, and shell and star fish no more grew upon the land than they do now. In other words there is no greater assumption in archæological than in the historical conclusion. But the difference is this, the archæological is, on the whole, more trustworthy than the other, because no human hand has been able to meddle with the evidence which is in the rocks. We may pursue this course of inquiry further and we find that while all this great plain which forms the foundation of the city belongs to some of the oldest rocks on the globe, this high land of the Cumberland district belongs to what is called the carboniferous formation, both silurian and carboniferous being parts of an extremely ancient period of the world's history. But when we come to these beds which lie westward toward the Mississippi, we come to something quite different. There is evidence here of this land having been worn away, and that these beds were originally the bottom of the sea. Then they have been upheaved. That evidence is clear, because we find upon these beds shellfish and others which can only live at the bottom of the sea. These belong to a much later period of the world's history, what we call the period of tertiary formation. Among these beds is what is known as green sand, prized by your agriculturists on account of its fertilizing qualities. To show how perfectly trustworthy our conclusions are with reference to this green sand being formed at the bottom of the sea, in that remarkable cruise in which the Challenger, a British vessel, has just completed a tour of discovery they have brought back abundant evidence that in some parts of the existing sea bottom green sand is formed, not different in its character from that which forms the ancient crust of the earth, and it is actually being formed now under these conditions. And though we had no reason to doubt the genuineness of geological evidence, it is now supplemented by observations not confined to one locality, but extending over the whole globe, by means of which we fill up this evidence that exists here and elsewhere. For example, that shows us that the ancient history of the world presents no sudden appearance of animal or vegetable formation—no great catastrophes or deluges, but a slow and even and gradual progress extending through periods of time of which it is almost impossible for even the most vivid imagination to form an adequate conception. I know it is thought very often that men of science are in the habit of drawing largely from their imagination, but it's really not so. The most sober, careful consideration of facts forces upon you more and more determinedly the conviction that the theory respecting which we have this geological evidence of a period of the past history of the world is of a duration which, in comparison with our human standard, may be regarded as almost absolutely infinite.

Take, for example, the case of the cataract of Niagara, where I have been recently spending some time, so that I might fill myself with the grandeur and beauty of that extraordinary natural phenomenon; it is quite easy to see that the Niagara River has formed its own valley, has cut its way back through the plateau of rock from which it falls, for some six miles. There is not the slightest difficulty in seeing that. The great cliff from which it tumbles is formed of two kinds of rock—hard rock at the top and soft rock underneath. The water undermines the soft rock below, when the solid stratum above falls over. You can trace the gradual excavation of that valley for six miles from that marvelous bluff which, from Proctor's monument, overlooks the plain of Ontario. Now, the rate at which that work is going on, has not yet been positively ascertained; but we may be perfectly certain (I am now speaking largely within limits) that the work of cutting back does not go on at the rate of a yard in a year. We have six miles of such cutting, which will bring you to a period of 10,000 years for the cutting back of Niagara alone. It is an immaterial matter to me how many years it takes, but it would be nearer probability, much nearer the truth, if I said three or four times that amount. What relation does a period of that kind bear to the vast duration expressed by these great ledges of strata which form the globe? We are a people curious enough to form a very distinct calculation of this. The sides of the ravine through which Niagara is cutting its way are formed by masses of

alluvial matter, which must be older than the river which has cut through it. In that alluvial matter you find the remains of shell-fish undistinguishable from those which now inhabit the lake, and along with them you find—as have been found—the teeth of the mastodon, which we know, from abundant evidence, was an inhabitant of the continent of North America at a comparatively recent period—the very last step of that long series of changes, of which the limestone upon which you are now standing indicates one of the older ones.

Thus it follows that the whole work of Niagara occupies less than one period of this vast duration. In relation to this duration of time, that of 10,000 years, or whatever else it may have been, is but an infinitesimal fragment of time, so far as the great phenomena of the globe are concerned. During that greater time the population of the globe has undergone a slow, constant, and gradual change, one species giving away to another. We have passed, by slow and gradual methods, without vast and sudden changes, into that state of things which obtain at present. I need not say that this view of the past history of the globe is a very different one from that which is commonly taken. It is so widely different that it is absolutely impossible to affect any kind of community, any kind of parallel, far less any sort of reconciliation between these two. One of these must be true. The other is not.

Then we may apply our talents to determine that one rests upon a record that cannot be interfered with—cannot be tampered with, cannot be altered by the stupidity or malice of man, and I think that it is in that one we must place our faith. If this be so, it is perfectly clear that the teaching of physical science in our schools has a much higher, much more important bearing upon the advancement of physical and material well-being. It is by the due and proper and practical teaching of the laws of science that men are rendered competent to judge of what we call the evidence of the past. It is quite useless for persons who have not been so trained to attempt to pick out of books what is said of those matters—they will simply cut their fingers by using tools which they are not competent to handle.

It is highly important that we should believe that which is true and not that which is false. So I put in these arguments as a plea for a thorough and careful training in science in the elementary education of our youth.

It is a curious thing, ladies and gentlemen, but I suppose I am a sort of fanatic in this matter, for I generally find, in addressing a public audience, whatever I begin upon, if the topic be a general one, I come back to this subject of scientific instruction. It is to me, upon practical grounds, of such vast importance, that I am sure you will forgive me on this occasion if I ride my hobby before you. And if I can do nothing else than leave you something else to think about as the result of my visit to Nashville, all that remains to me on this my first occasion of addressing an audience in the United States, is to thank you, not only for yourselves, but for your fellow-countrymen, for the extreme kindness with which I have been received everywhere in this country. I was wholly unprepared to find so great a body of friends and kindly disposed persons as I have met here, and I can only hope that whatever it may be permitted to me to do in the future, I may be enabled to render some justification for your abundant kindness. I wish you farewell.

UNIVERSITY EDUCATION.

PROF. HUXLEY'S ADDRESS AT BALTIMORE.

A CORDIAL RECEPTION—THE FORMAL OPENING OF THE JOHNS HOPKINS UNIVERSITY—A FEW PLAIN WORDS FOR TEACHERS AND SCHOLARS—A GLANCE AT THE POLITICAL HORIZON OF AMERICA.

The formal opening of the Johns Hopkins University at Baltimore took place Sept. 12, at 11 a. m., in the Academy of Music. Prof. Huxley delivered the opening address. The rare opportunity was appreciated by the citizens of Baltimore in general and by the many learned professors and teachers in the vicinity, who filled the Academy almost to its capacity. Prof. D. C. Gilman, formerly of Yale, and more recently President of the University of California, now President of the Johns Hopkins University, occupied the chair. Among others on the platform were Gov. John Lee Carroll, Mayor F. C. Latrobe, nearly all the Faculty of the university—including the professors, lecturers, associates and fellows, and the trustees—Chief-Judge George Wm. Brown, John W. Garrett, Chas. J. McGwinn, Attorney-General of Maryland, and Reverdy Johnson. There were also present Dr. J. A. Stewart, Health Commissioner; Profs. Christopher, Johnston, and Howard of the Medical University, representatives of the clergy and of the Academy of Sciences, and many prominent lawyers. The venerable Prof. N. R. Smith sat by the side of the presiding officer.

The following are the general plans of the Hopkins Trustees: Their endowment is ample, available, and free from conditions. Its management is free from political and sectarian control. Its purpose is to make an addition to the resources of American education, and not to rival or duplicate any existing foundations. The buildings are temporarily provided in Baltimore and are inexpensive, but include ample laboratories of chemistry, physics, and

biology. Instruments and books have been liberally ordered. The teachers have been selected because of their distinction as specialists, and are of four classes—professors, lecturers, associates, and fellows. While some of these are of renown, like Sylvester and Gildersleeve among the professors, and Whitney, Lowell, Child, Newcomb, Walker, Hilgard and Cooley among the lecturers, many are young men who give promise of equal celebrity. There are already enrolled, as associates, fellows, and resident graduates, 40 young men who have been graduated within the last ten years from American colleges, of whom 12 have pursued prolonged courses in Europe, six have taken the degree of M. D., and six that of Ph. D. The Johns Hopkins University is said to be the only institution in the country which has begun with such a staff of graduates.

The lecture was preceded by a brief introduction of Prof. Huxley by Prof. Gilman, which was exceedingly graceful and complimentary. In it he welcomed the lecturer to this country, not merely as a man of science, but also as a teacher from whose predecessors and associates American institutions of learning had always been proud to accept aid and counsel. Prof. Huxley's lecture occupied an hour and a quarter in delivery, and was given in an easy, conversational tone, and at a speed not exceeding 120 words a minute. In this respect he appears unusual to American audiences familiar with the race-horse rapidity of Froude, Proctor, and Kingsley. In his appearance and accent his nationality would be at once recognized. Before the conclusion of his lecture he stepped aside from his theme to discuss very briefly and very soberly the future prospects of America as a nation, the responsible task she has before her in the solution of the problem of a republican form of government, and the honor or disgrace to result from this great political experiment. At this portion of the lecture the applause was very emphatic, and when the Professor concluded with a feeling allusion to his own honest and hearty hopes of a successful issue, the audience signified their approbation vehemently.

THE ADDRESS.

GENTLEMEN OF THE BOARD OF TRUSTEES OF THE JOHNS HOPKINS UNIVERSITY: The actual work of the university founded in this city by the well-considered munificence of Johns Hopkins commences to-morrow, and among the many marks of confidence and good will which have been bestowed upon me in the United States, there is none which I value more highly than that conferred by the authorities of the university when they invited me to deliver an address on such an occasion. For the event which has brought us together is in many respects unique. A vast property is handed over to an administrative body, hampered by no conditions save these: That the principal shall not be employed in buildings; that the funds shall be appropriated in equal proportions to the promotion of natural knowledge, and to the alleviation of the bodily sufferings of mankind; and, finally, that neither political nor ecclesiastical sectarianism shall be permitted to disturb the impartial distribution of the testator's benefactions. In my experience of life a truth which sounds very much like a paradox has often asserted itself, viz.: That a man's worst difficulties begin when he is able to do as he likes. So long as a man is struggling with obstacles, he has an excuse for failure or shortcoming; but when fortune removes them all, and gives him the power of doing as he thinks best, then comes the time of trial. There is but one right, and the possibilities of wrong are infinite. I doubt not that the trustees of the Johns Hopkins University felt the full force of this truth when they entered on the administration of their trust a year and a half ago; and I can but admire the activity and resolution which have enabled them, aided by the able president whom they have selected, to lay down the great outlines of their plan and carry it thus far into execution. It is impossible to study that plan without perceiving that great care, forethought, and sagacity have been bestowed upon it, and that it demands the most respectful consideration. I have been endeavoring to see how far the principles which underlie it are in accordance with those which have been established in my own mind by much and long-continued thought upon educational questions. Permit me to place before you the result of my reflections.

ELEMENTARY EDUCATION.

I think there are two aspects under which we may consider a university. It is, in the first place, a teaching institution; and it is, in the next place, an institution for advancement and increase of knowledge. Under the first aspect, it is obviously and clearly connected with the general system of education; and it stands in some definite relation, or should stand in some definite relation, with the primary school, with the elementary school. And therefore it may behoove us to consider, in the first place, what elementary education should be taught. For in the view which I hold, the university, as a department of the primary school, simply places a crown and a summit upon the education which is given in the primary school. As to what should be the nature of elementary education, I have long held opinions which are, I am happy to say, becoming more popular than they once were, but which still may diverge a good deal from ordinarily received ideas. I am of opinion that an elementary education should discipline all sides of the mind, and should leave no important faculty uncultivated. At its foundation lies a knowledge of the English language, the tongue we speak; power of reading; power of writing with accuracy and ease; and, finally, that amount of cultivation, of taste, and judgment which is to be derived from the study of the higher English authors. I think again that it is an essential part of elementary education that the scholar should learn at any rate the elements of the history of his own country. It is hard for any boy or any girl who has not lived a life, to understand history; perhaps impossible. But nevertheless it is useful, for the mind should be furnished those fundamental facts. I look again upon the elements of

the physical sciences as a fundamental part of elementary education. The elements of physical geography, the elements of physics, the elements of chemistry, the elements of human physiology—all these are matters of great and increasing moment, and there is no reason why they should not be taught in our elementary schools as well as the mass of things which are taught in our institutions—elementary mathematics, arithmetic, and geometry. I should be disposed to think that archæology is best taught practically—not so much theoretically as practically.

And, finally, I conceive that it is an essential part of elementary education that the æsthetic faculty should be trained; that some knowledge of music should be given, and that every one should be taught to draw according to his capacity. In these matters of art people vary indefinitely in their individual capacity. You cannot make an artist of anybody who is not born one. You may make an appreciator of art, and a useful knowledge of art may be acquired by those who possess but a very small 'innate capacity. Such education should enable an average boy of 15 or 16 years to read and write his own language with ease and accuracy, and with a sense of literary excellence derived from the study of our classic writers; to have a general acquaintance with the history of his own country, and with the great laws of social existence; to have acquired the rudiments of physical science and a fair knowledge of elementary arithmetic and geometry. He should have obtained an acquaintance with logic rather by example than by precept, while the acquirement of the elements of music and drawing should have been pleasure rather than work. It may sound strange to many ears if I venture to maintain the proposition that a young person, educated thus far, has had a liberal though perhaps not a full education.

It seems to me that such training as that to which I have referred may be termed liberal with perfect accuracy in both the senses in which that word is employed. In the first place it is liberal in breadth. It extends over the whole ground of things to be known and of faculties to be trained, and it gives equal importance to the two great sides of human activity—art and science. In the second place, it is liberal in the sense of being an education fitted for freemen—for men to whom every career is open, and from whom their country may demand that they should be fitted to perform the duties of any career. I cannot too strongly impress upon you the fact that with such a primary education as this, and with no more than is to be obtained by building strictly upon its lines, a man of ability may become a great writer or speaker, a statesman, a lawyer, a man of science, painter, sculptor, architect, or musician. That even development of all a man's faculties which is what properly constitutes culture, may be effected by such an education, while it opens the way for the indefinite strengthening of any special capabilities with which he may be gifted. In a country like this, where most men have to carve out their own fortunes, and devote themselves early to the practical affairs of life, comparatively few can hope to pursue their studies up to or beyond the age of manhood. But it is of vital importance to the welfare of the community that those who are relieved from the need of making a livelihood, and still more those who are stirred by the divine impulse of intellectual thirst or artistic genius, should be enabled to devote themselves to the higher service of their kind as centers of intelligence, interpreters of nature, or creators of new forms of beauty; and it is the function of a university to furnish such men with the means of becoming that which it is their privilege and duty to be.

OBJECTS OF THE UNIVERSITY.

To this end the university need cover no ground foreign to that occupied by the elementary school. Indeed it cannot; for the elementary instruction which I have referred to embraces all the kinds of real knowledge and mental activity possible to man. The university can add no new departments of knowledge—can offer no new fields of mental activity; but what it can do is to intensify and specialize the instruction in each department. Thus literature and philology, represented in the elementary school by English alone, will extend in the university over the ancient and modern languages. History, which, like charity, best begins at home, but, like charity, should not end there, will ramify in the university into the history of other countries, theology, and numismatics, and all matters bearing thereupon; and in a well-constituted university we have, as adjuncts to these two lines of study, libraries containing necessary books. So, again, science, represented by the mere study of its rudiments in the elementary school, will in the university be represented by a complete faculty; such sciences as those I have enumerated will be taught and carried to their highest extent by special professors, and instructions given in the lecture-room will be supplemented—and this is the most essential part of the proper teaching of physical sciences—by practical work in a duly constructed laboratory under the superintendence of the demonstrators.

So understood, the study has that which makes it different from other disciplines, namely, the bringing of the mind of the student in direct and immediate contact with fact, so that it does not depend upon treatises but upon actual conception of Nature as she is. And that is only to be given by the addition of practical laboratories to the ordinary appliances of teaching. So I need hardly say that the English language will serve in another direction, affording some basis for philological study in the school, which will branch out in the study of all the ancient and modern languages, regarded as a matter of philology and not of literature. Mathematics will soar into its highest regions, while the high peaks of philosophy may be scaled by those whose aptitude for abstract thought has been awakened by elementary logic. And in any thoroughly constituted university I should hope to see and think essential the means for the study of art. Not only the elements, but the greatest refinements of art could be taught. Schools of pictorial

and plastic art and architecture and of music should offer a thorough discipline in the principles and practice of art to those in whom lies nascent the rare faculty of æsthetic representation, or the still rarer power of creative genius. Having elementary schools of the kind to which I have referred at one extremity and the university at the opposite extremity, we should have the Alpha and Omega of education—the alphabet complete. Under some circumstances and in some countries it is desirable to have what I have called elementary education divided into a primary and a secondary school. In other cases it is not essential: but that is a matter of secondary importance.

THE MEDICAL SCHOOL.

One great object of the Johns Hopkins bequest, as I understand, was the establishment of a hospital, and, in connection therewith, a medical school, and it was the desire that the education given by the university should be so contrived as to subserve the interests of medical education. There is no doubt that the subject of medical education is an extremely important one. It is partly from my early education, partly from the fact that I was for many years one of the examiners of the University of London, which is supposed to have the highest standard of education in England, and partly from other reasons, that I have taken a particular interest in this subject, and I am very glad to be able to say a few words upon it here, and more because I must confess that, among the many satisfactory and striking institutions which I have met in this country, probably the manufacture of medical men is not the most striking nor the most essential. In a matter of this kind there is no advice better than the advice of Dr. Johnson—"Above all things, Sir, clear your mind of cant"—and there is a good deal of cant about education, and I think a cant in respect to the medical profession is a notion vague and misty to the last degree—still powerful—that the medical profession ought to be a sort of liberal profession. When you come to analyze that, I think it comes to this, that a doctor ought to be able to construe Celsus, so long as that is enforced upon him.

There is a sort of a notion that the profession has a sort of general liberal principle. I do not agree with that notion. I have a very strong conviction that what constitutes dignity in a profession, without which you can have no liberality at all, is that members of that profession should be able to do exactly what the public give them credit for being able to do, and I shall proceed upon that ground in arguing upon the kind of education which I think is needful in order to bring the medical profession into the study which the public have a right to expect. It should be the pledge which a medical man freely gives to the public by announcing himself as such. It is that each shall have done his best to qualify himself to prevent, to alleviate human suffering, to cure disease. That is the understanding upon which he announces himself as a medical man, and upon which the public pay him for his services. To do his business is to be that. If he has time he may put it to any use, but his first business is to be that. Indeed, in order that a physician should be able to understand the causes which lead to disease and to alleviate suffering, the first condition is that he should understand the conditions of health, that he should understand the workings of the human body, and should comprehend the parts that compose it.

A PHYSICIAN'S STUDIES.

The studies which embrace the kind of knowledge necessary for this purpose are what we call human anatomy and physiology, and without an exceedingly clear conception upon these two subjects the attainment of anything like a rational medical practice is quite out of the question. Nobody can understand physiology without a certain amount of knowledge of elementary chemistry and physics, and the application of these to living matter. If the medical man is to be a surgeon he must have a knowledge of surgery; he must have a knowledge of the action of drugs—what we call therapeutics—a knowledge of diseased structures and the consequences of disease, which runs under the name of pathology. These being the special requirements of the medical man, and a medical school being properly a technical school attached to a university, what we should like for any medical school is a thorough and complete instruction in these matters. I mean such instruction, such a mode of learning, that a man shall understand the facts of anatomy and physiology, and have them at his fingers' ends, just the same as he has his daily business, because the medical man has to act upon his knowledge promptly and quickly, and come to a conclusion based upon his knowledge; and it ought to be as familiar to him as the actions upon which he bases his daily labor.

Such being the case, we have to reflect that the practical necessities of life are such, that very few medical students can expect to give more than three, or at the outside, four years of their life to the special study of their profession. As things stand at present, a young man who is perfectly raw, has simply an ordinary school information, not a conception of physical science, probably never having looked through a microscope, comes to a medical school, and in the course of four years he is supposed to acquire, he ought to acquire, if he is to be an honest man and a good practitioner he must acquire, a knowledge of physiology, pathology, therapeutics, obstetrics, and other branches of medicine; and to these he should add a certain acquaintance with medical jurisprudence, inasmuch as evidence may be called for in trials in court, where, upon his certificate, men may be torn from their homes and families and confined in a lunatic asylum; and it is also desirable that he should have some acquaintance with psychology, and all must be done in four years. If this is to be done, if a sound education is to be given that breaks the backs of most of those who try to go through it, the most careful attention is to be paid to the easing of the process, by, in the first place, cutting off everything which is not absolutely essential.

NATURAL HISTORY FOR THE STUDENT.

In the many medical schools of the present day

young men are set down to spend three or four valuable months of the year in the study of zoölogy and comparative anatomy and botany and *materia medica*—that is, a knowledge of drugs and what they come from and the animals and plants that yield them. If I had power in this matter I should cut all these subjects out ruthlessly. You will understand that I am not a likely man to discourage the study of zoölogy and comparative anatomy and botany. I have the greatest respect for botany and for drugs and druggists as far as that goes, but in medical education one has to recollect the great truth that "in order to know a little well, you must be content to be ignorant of a great deal." Although no one would be more unwilling than I to cast the slightest doubt upon the studies that I have mentioned in their places, I do maintain that in the medical curriculum they are out of place. When the time which a man possesses to become familiar with the structure of the human body—which is no easy business—when that is so limited, what earthly business has he to be studying the anatomy of star-fishes and crabs and lobsters? He is not going to operate on star-fishes and crabs and lobsters, except in a gastronomical and non-surgical way. Very valuable as that knowledge may be in other departments, it has not the remotest bearing upon his proper professional pursuits.

SYSTEM OF EXAMINATION.

Another great improvement, in my judgment, might be made in the system of examination. It is not many years since I was a medical student in London, and the practice was that the examination was held at the end of three or four years' study, and it was no uncommon thing for a young man to have to attend four or five lectures on as many different subjects, to work in the dissecting-room, and have to attend hospital practice all in the same day. The remarkable jumble, sort of "pi" in the printer's sense, that was thus created was an astonishing thing. One would have thought that the inventors of such a system intended to put a stop to anything like an acquisition of sound knowledge, and I must say that they were quite successful. The ordinary practice was, that when one tried to carry all these things in his head it was out of the question for him to do so. If he was an industrious man, he attended to one or two things well until the examination, and then trusted to the work of the "grinder" for the last six months to prepare him to sit down at the table and answer any questions that might happen to turn up in the minds of the examiners in eight or nine subjects. We have classified studies since then and arranged it so that young men have much more chance than they used to have. But I believe that an improvement might still be made in the same direction, an important improvement, which has been suggested some time since; namely, to allow the medical student to pass his examination at the end of his course of lectures, to concentrate his whole mind upon the subject at which he is working, and then let him take his rank or position finally by the kind of examination that he passes through at the end of his lectures. It is a plan that has been pursued for many years at the Royal School of Mines, and we have found it to succeed admirably well. It allows the student to concentrate upon his mind what he is about for the time being, and then practically to dismiss it.

Those who have to do with intellectual work will agree with me that the important thing in this life is not so much to know a thing as to have known it and known it thoroughly. If you have known a thing thoroughly in the first place, you know where to find it when you have forgotten it, and when you begin to work again all the grooves are made quite easy, and knowledge comes back with great facility. [Applause.] Then there was a question of how far and in what way education in the university can be subserved to that given in the medical schools. I look here not only to the university; I look further back to the elementary schools. If instruction in the elements of physics and chemistry and human physiology—if that is given in our elementary schools in the way in which it may be given, in the way in which it ought to be given, as part of everybody's information, it will have a most remarkable influence upon medical education.

Thus in the medical curriculum, if that ordinary education is properly carried out, the medical student will come to the university with work already done which at present occupies much of his time and attention. That is not the only result, nor the most important result. The still more important result is that he will come with his mind accustomed to scientific ideas and with his eyes trained to observe. You cannot imagine what enormous difficulty is thrown in the way of scientific education by our existing system. It is not only with men who have studied nothing but books, having no acquaintance with modes of observation; but it is a habit of men which begets—I was going to say—a disgust of observation. I find many of my own students, who come to me in that way, who will do anything rather than believe a fact they can see with their own eyes. I have had men working with the microscope whom we require to draw the object they see through the microscope, and I have seen them draw off my diagram on the blackboard, which they would much rather draw than the thing actually under their eyes. I suppose the person who is embarked in the medical career to go to the university provided with such instruction in elementary science as I have indicated, and then he comes within reach of the university and falls into the hands of the pathological department of the university, and there, with the systematic study of botany and other studies which I have referred to—there he becomes acquainted theoretically and practically with the great principles, and it is from that foundation that he steps on to his special medical studies. I believe that such preparation as this and with the trained habits and powers with which the medical student will come to his special study, is better than to come to it raw

and with no preparation. I believe we may consider it as practically doubling the time of professional study.

THE INVESTIGATION OF TRUTH.

These are the remarks which I venture to offer to you respecting the university considered from its educational side. But, as I said at starting, there is another side to a university. It is given to everybody to learn more or less, but it is given to very few to increase the stock of knowledge. It is perhaps even more rare that a man should possess the creative faculty in art. It is a difficult thing even to get the power of accurate representation in art. But whether in literature, or in painting, or in sculpture, the creative power, as you know, is one of the rarest of faculties—rarer, I think, than the power of scientific investigation. But rare as these powers may be, and indeed in virtue of their rarity, does it devolve upon the community to provide the means by which the persons possessing them can open a career for themselves and devote themselves, as all such men do, whether consciously or unconsciously, to the high service of the community. For it is assuredly true that man does not live by bread alone, but by ideas, and it is unquestionable that the future of this world lies in the hands of those who will supply the world with ideas and in some way furnish the masses of mankind, who have not the time or the inclination or the capacity to think out things themselves, with some theory of things that is not too absolutely inconsistent or too absolutely absurd to serve some practical purpose.

Therefore it is the highest duty of a university to find a system which shall discover and protect these powers of artistic creation, and the investigation of new truths which are the two great sides of active, or what we may call the original, or creative, or investigative human mind. The problem which I have referred to, the endowment for research, has been in England greatly discussed among us, and you will find in the report of the Royal Commission, I think, almost all that is to be said upon this most remarkable question. There are many persons who seem to think that the sole question is one of money. Endowment of research rather expresses that notion, that the power of investigation or the power of creation in art, like other things, follows the laws of supply and demand; pay for it and you will get it. That is a notion that does not commend itself to my mind. I do not think we shall get a man of genius by merely going into the open market and offering money. On the contrary, I am afraid that such a purely commercial way of looking at the matter is likely to yield purely commercial results, and that the door would be open on such principles for indefinite nepotism and indefinite jobbery. To my mind the problem is one of the most difficult problems that can meet practical men. I entirely concur in the principles laid down in your trustees' address. I mean in the principle that the safest and best thing to do in the way of endowing research is to offer offices, the payment for which is sufficient to maintain a man, to such persons as think themselves competent to become investigators, but to require of them something or other. And I believe the most healthy and sound requirement is a certain amount, not too much, but a certain amount of teaching. I know of nothing else which is more likely to prevent the evils which always wait about money power, wherever it may be. I know of nothing which is so likely to prevent those evils as the creation of offices and posts made for men who are capable of original research—offices for teaching in some shape or other. It offers their colleagues a knowledge of what they are about, and the public a knowledge of what is being done. I think to well constituted minds it must be a satisfaction thus to know that they are thus exercising a direct influence upon their cotemporaries.

THE PROGRAMME OF THE UNIVERSITY.

Now, ladies and gentlemen, I think I have said all that I can conveniently say at present upon these topics of university and elementary education. Of course, the subject is one upon which I could enlarge to any extent, but on the present occasion I have indicated with sufficient clearness what general ideas I have to lay before you, and I may now turn to the question which I took the liberty of saying I might deal with, namely, the plans adopted by your trustees and your president for this university. So far as I am able to judge, they are most wisely and soundly conceived. One conclusion at which they have arrived is entirely in accordance with some very strong prejudices—I suppose I ought to call them—of my own. They propose not to build at present, but accommodate themselves and see how things will go on. I do not know what would be the course in America, but in England very curious things happen when people begin to build. I have seen great educational funds fossilized into mere bricks and mortar, just as if architecture is a kind of petrifying stream, and with nothing left to work them. You know there was an ancient warrior who was said to have made a desert and called it Peace. Well, I have seen administrators of educational funds who have made a palace and called it a university.

I am so strongly impressed with this feeling that I will venture to say to your trustees to-day that I hope they won't think of building by any hands higher than those of a bricklayer, who will do for them exactly as they want and nothing else. Perhaps until such time as the Baltimore and Ohio shares have gone up to $1,000 premium, and when every professor is as fully endowed as he wishes to be, and every library is as large and well furnished as it ought to be, and when there is nothing more you want or would want, then if there are a few hundred thousand dollars left, send for an architect and let him put a façade on the edifice. If you do anything else you will get a building which will contribute very much to his fame but not to your need. From what I have said respecting the relations of the university and education in general, it will be obvious to you that I have nothing to object to, nothing to criticise in the arrangements which have been proposed by your trustees for the work of this university. Nothing can be more

complete, more broad, than the view which they take of what the university should do. Nothing can be better, in my judgment, than the provision which they have made for that delicate and difficult business of the endowment of those who are competent to make research and to investigate. I understand that, although there is not likely to be, perhaps, in the university itself a department specially devoted to the cultivation of art, yet you have great institutions like the Academy of Music or the School of Art, which can be with great readiness affiliated with and brought into relation to your university.

Probably one of the great practical difficulties you will have to meet with will be the sort of limitation which it will be necessary to put upon the persons admitted to your university. No doubt, on one hand, it is very important that those who come to the university should be prepared to take advantage of its higher instruction. No doubt, on the other hand, it is of immense importance, especially in a young country like this, that no artificial barrier should be put in the way of men of ability, who occur in all strata of society, finding their way to the principal places through the means of the university. It is just by that Scylla and Charybdis that your authorities will have to steer their way. It may be a question how far their end may be attained by examination at the end of the first course of instruction. It so often happens that aspiration in this world is taken for inspiration, and that a young man who thinks he has great capacity when tested turns out to have ambitions and no powers. It is undoubtedly most desirable to eliminate persons of that kind as soon as possible, and it may be a question how far that is best done by an examination at the end of the first term, or by a preliminary examination; but I must honestly say that my own feeling is very strong against any sharp, cut-and-dried matriculative examination; and there have been many instances, especially in the direction of science, where boys who have had no advantages or power of preparing themselves by matriculative examinations have been, nevertheless, persons who have attained to the greatest distinction and have been of the greatest service to their kind by means of such aid as the university can afford.

Another very important and difficult question, which I can hardly hope to discuss here, is the problem of testing capacity in a course of university career—the problem of conferring degrees. There is much to be said in favor of an open curriculum—of allowing people to choose what they like. Of course it is out of the question to suppose that any one man, if he were the Admirable Crichton twice over, could cover the whole ground. Every man must take a special line, and then if you want degrees as the reward of proficiency, I think it necessarily follows that the line of work must be defined; because, if you grant degrees at all, one must be as valuable as the other, and that almost seems to me to imply some sort of definite curriculum.

THE FUTURE OF AMERICA.

But questions of that kind can only be indicated here, and require great care for their practical settlement. Indeed I think it doubtful whether it were wise of me to touch more fully upon the many topics which are indicated here in my notes. Let me rather say in conclusion that I have often been struck in England with the charm which Americans seem to feel in visiting those ancient cities of ours or climbing the battlements of crumbling castles, the names of which are inseparably associated with the great epochs of our noble literature, or with the various steps of that blood-stained progress by which the savage Briton or the wild pirate of the North Sea has become converted into the champion of order, chief means of the progress of civilization. It is impossible to be otherwise—as an Englishman—than in entire sympathy with a feeling of this kind; but if retrospect has its charm, I think it is no less true that there is a joy in anticipation; and to an Englishman who first lands upon your shores, who finds himself traveling for hundreds of miles through what I can only call strings of great cities, who even in the roughest way compares the extent of your territory with that which he has left, and looks at your marvelous resources in everything that tends to the welfare and riches of mankind, there is a something sublime in the vista of the future.

I don't say this with the least intention of flattering that particular vulgar sentiment which is commonly called national pride. On the contrary, I don't know that I have any particular respect for bigness as such or for wealth as such, and most assuredly bigness is not the same thing as greatness, and territory does not constitute a nation. What I referred to just now as the issue which had suggested itself to me, fraught, as I will say it again, with a certain sublimity, a terror as of overhanging fate, is the question: What are you going to do with all these things? To what purpose will you put this great store of material wealth and this vast amount of human intelligence and capacity which is among you to deal with? The question is one which, it seems to me, no man has a chance of answering with the remotest probability at the present moment.

You are undertaking the greatest political experiment that has ever been performed by any people whatever. You are at this present centenary a nation of 40,000,000 of people. At your next centenary rational and probable expectation may look to see you 200,000,000, and you have before you the problem whether 200,000,000 of English speaking, strong-willed people will be able to hold together under the form of republican institutions and under the real despotism of universal suffrage [a burst of applause]; whether State rights will hold their own against the necessary centralization of a great nation, if it is to act as a whole, or whether centralization will gain the day without breaking down republican institutions. The territory you cover is as large as Europe, as diverse in climate as England and Spain, as France and Russia, and

you have to see whether with the diversity of interests, mercantile and other, which arise under these circumstances, national ties will be stronger than the tendency to separation; and as you grow and the pressure of population makes itself manifest, the specter of pauperism will stalk among you, and you will be very unlike Europe if communism and socialism do not claim to be heard. I cannot imagine that any one should envy you this great destiny—for a great destiny it is to solve these problems some way or other. Great will be your honor, great will be your position, if you solve them righteously and honestly; great your shame and your misery if you fail. But let me express my most strong conviction that the key to success, the essential condition to success, is one and one only; that it rests entirely upon the intellectual clearness and upon the moral worth of the individual citizen. [Applause.] Education cannot give intellectual clearness. It cannot give moral worth, but it may cherish them and bring them to the front; and in that sense the university may be and ought to be the fortress of the higher life of the nation. [Applause.]

It is my most earnest wish and hope that the university, the career of which begins to-day, may fulfill this high mission to its fullest extent [applause]; that its outgrowths may become centers of intelligence, foci of intellectual life in the United States; and on the next centenary of your Republic let me hope that you will attain such a position that the students of all nations will flock here as in former days they flocked to Oxford, to Paris, and to Bologna. [Applause.] Permit me to fancy that among the English part of that population there may linger a dim tradition at that time that at the commencement of your work an Englishman was permitted to address you as he has done to-day, to look upon your hopes as his hopes, and to consider your success as his joy. [Great applause.]

EVIDENCES OF EVOLUTION—I.

PROF. HUXLEY AT NEW-YORK.

THE UNTENABLE HYPOTHESES.

THE PROBLEM OF THE WORLD'S ORIGIN—THREE HYPOTHESES TO ACCOUNT FOR IT—THE HYPOTHESIS OF ITS ETERNAL EXISTENCE, THE MILTONIC HYPOTHESIS, AND THE HYPOTHESIS OF EVOLUTION — TESTIMONIAL EVIDENCE IMPOSSIBLE; CIRCUMSTANTIAL EVIDENCE OF THE HIGHEST VALUE—GEOLOGICAL PROOF THAT THE FIRST AND SECOND HYPOTHESES ARE UNTENABLE.

To say that a crowded audience greeted Prof. Thomas H. Huxley at Chickering Hall on the night of Sept. 18, is to do injustice to the fact. The entrance was thronged at an early hour, and the only consolation of the people who were jammed together in front of the ticket office was that it was a highly respectable crush. Large numbers had evidently deferred the purchase of tickets until the last moment. The trouble was not ended when, after undergoing the last extremity of squeezing, the ticket office was reached and the purchase made. It was quite as difficult to get out from the crowd below as it was to get into it. Not a few agile gentlemen took the alternative of climbing up the sides of the stairs to join the happier throng that they had been long envying—the people that had bought their tickets in advance and had nothing to do but to ascend to the hall.

Within, every seat seemed to be taken before the lecture began, the few vacancies were filled during the first ten minutes afterward, and "wall-flowers" were packed standing behind the seats. The hall was full of familiar faces; of men eminent in the learned professions; of New-York's best society. Punctual to the very minute Prof. Huxley came forward upon the platform, and was of course greeted with abundant applause. He laid a copy of Milton's Paradise Lost upon the reading desk; nothing else, neither manuscript nor notes. He leaned forward slightly over the desk and began speaking in measured words and with a low tone of voice. Except sometimes to grasp the desk with both hands and lean over it more intently, he did not vary his position or make use of gestures during the lecture.

At first Prof. Huxley was not distinctly heard by the entire audience, but after the noise made by people entering had subsided, there was less difficulty in this respect. He was listened to with the closest attention throughout, and the perfect silence of the audience, except at rare intervals when applause was called forth, gave striking evidence of the interest that was taken, notwithstanding the closeness of the argument and the absence of popular features in the discourse.

THE LECTURE.

LADIES AND GENTLEMEN: We live in and form a part of a system of things of immense diversity and perplexity which we call nature, and it is a matter of the deepest interest to all of us that we should form just conceptions of the constitution of that system and of its past history. With relation to this universe, man is in extent little more than a mathematical point, in duration but a fleeting shadow. He is a reed shaken in the winds of force, but, as Pascal long ago remarked, although a reed, he is a thinking reed, and, in virtue of that wonderful capacity of thought, he has a power of framing to himself a symbolic conception of the universe, which, although doubtless highly imperfect, and although wholly inadequate as a picture of that great Whole, yet is sufficient to serve him as a guide-book in his practical affairs. It has taken long indeed, and accumulations of often fruitless

labor, to enable man to look steadily at the glaring phantasmagoria of nature, to notice her fluctuations and what is regular among her apparent irregularities; and it is only comparatively lately, within the last few centuries, that there has emerged the conception of a pervading order and a definite force of things, which we term the course of nature. [At this point cries of "Louder! louder!" which had been uttered once before, now became general, and a gentleman called from the back of the hall, "We can't hear a word you say," to which the lecturer responded by saying, "If my audience will be so kind as to be seated that difficulty will be largely removed." He then resumed his lecture in a tone of voice scarcely raised, but more audible on account of the instant hushing of noise and movements.]

But out of this contemplation of nature, and out of man's thought concerning her, there has in these later times arisen that conception of the constancy of nature to which I have referred, and that at length has become the guiding conception of modern thought. It has ceased to be almost conceivable to any person who has paid attention to modern thought, that chance should have any place in the Universe, or that events should follow anything but the natural order of cause and effect. We have come to look upon the present as the child of the past and as the parent of the future; and as we have excluded chance from any share or part in the order of things, so in the present order of nature men have come to neglect, even as a possibility, the notion of any interference with that order; and whatever may be men's speculative notions upon these points, it is quite certain that every intelligent person guides his life and risks his fortune upon the belief that the order of nature is constant, and the relation of cause to effect unchanged.

THE QUESTION A HISTORICAL ONE.

In fact, there is no belief which we entertain which has so complete a logical basis as that to which I have just referred. It underlies tacitly every process of reasoning; it is the foundation of every act of the will. It is based upon the broadest induction, and it is verified by the most constant, regular, and universal of inductive processes. We must recollect that any human belief, however broad its basis, however defensible it may seem, is, after all, only a probable belief, and that our broadest generalizations are simply the highest degrees of probability. Though we are quite clear about the constancy of nature at the present time, and in the present order of things, it by no means follows necessarily that we are justified in expanding this generalization into the past and in denying absolutely that there may have been a time when evidence did not follow a first order, when the relations of cause and effect were not fixed and definite, and when external agencies did not intervene in the general course of nature. Cautious men will admit that such a change in the order of nature may have been possible, just as every candid thinker will admit that there may be a world in which two and two do not make four, and in which two straight lines do not inclose a space. In fact this question with which I have to deal in the three lectures I shall have the honor of delivering before you, this question as to the past order of nature, is essentially a historical question, and it is one that must be dealt with in the same way as any historical problem.

I will, if you please, in the first place, state to you what are the views which have been entertained respecting the order of nature in the past, and then I will consider what evidence is in our possession bearing upon the question, and by what light of criticism that evidence is to be interpreted. So far as I know, there are only three views—three hypotheses—which ever have been entertained, or which well can be entertained, respecting the past history of nature.

HYPOTHESES RESPECTING THE ORDER OF NATURE.

Upon the first of these the assumption is that the order of nature which now obtains has always obtained; in other words, that the present course of nature, the present order of things, has existed from all eternity. The second hypothesis is that the present state of things, the present order of nature, has had only a limited duration, and that at some period in the past the state of things which we now know—substantially though not of course in all its details the state of things which we now know—arose and came into existence without any precedent similar condition from which it could have proceeded. The third hypothesis also assumes that the present order of nature has had but a limited duration, but it supposes that the present order of things proceeded by a natural process from an antecedent order, and that from another antecedent order, and so on; and that on this hypothesis the attempt to fix any limit at which we could assign the commencement of this series of changes is given up. I am very anxious that you shall realize what these three hypotheses actually mean; that is to say, what they involve, if you can imagine a spectator to have been present during the period to which they refer. On the first hypothesis, however far back in time you place that spectator, he would have seen a world, essentially similar, though not perhaps in all its details, to that which now exists. The animals which existed would be the ancestors of those which now exist, and like them; the plants in like manner would be such as we have now, and like them; and the supposition is that at however distant a period of time you place your observer, he would still find mountains, lands, and waters, with animal and vegetable products flourishing upon them and sporting in them just as he finds now. That view has been held. It was a favorite fancy of antiquity, and has survived along down toward the present day, and it is worthy of remark that it is a hypothesis which is not inconsistent with what geologists are familiar with as the doctrine of Uniformitarianism. That doctrine was held by Hutton, and in his earlier days by Lyell. For Hutton was struck with the demonstration of astronomers that the perturbations of the planetary bodies, however

great they may be, yet sooner or later righted themselves, and that the solar system contained within itself a self-adjusting power by which these aberrations were cured and it brought back to an equilibrium.

Hutton imagined that something of the same kind may go on in the earth, although no one recognized more clearly than he the fact that the dry land is being constantly washed down by rain and rivers and deposited in the sea, and that thus in a certain length of time, greater or shorter, the inequalities of the earth's surface must be leveled and its high lands brought down to the sea. Then taking in account the internal forces of nature, by which upheavals become seated and give rise to new land, these operations may naturally compensate each other, and thus substantially for any assignable time the general features of the earth might remain what they are. And inasmuch as there is no limit under these circumstances to the successive development of the animals and plants, it is clear that the logical development of this idea might lead to the conception of the eternity of the world. Not that I mean to say that either Hutton or Lyell held this conception—assuredly not; they would have been the first to repudiate it. But by the arguments they used it might have been possible to justify this hypothesis.

THE THEORY OF CREATION IN PARADISE LOST.

The second hypothesis is that to which I have referred as the hypothesis which supposes that this order of things had at some no very remote time a sudden origin making it such as it now is. That is the doctrine which you will find stated most fully and clearly in the immortal poem of John Milton, the English *Divina Commedia*, "Paradise Lost." I believe it is alone through the influence of that remarkable work, combined with daily teachings to which we have all listened in our childhood, that this hypothesis owes it general wide diffusion as one of the current beliefs of English-speaking people. If you turn to the VIIth Book of "Paradise Lost" you will find there stated the theory, the hypothesis to which I refer, which is this: That this visible universe of ours made its appearance at no great distance of time from the present day, and that the parts of which it is composed made their appearance in a certain definite order in the space of six natural days, in such a manner that in the first of these days light appeared; in the second, the firmament or sky separated the water above from the water beneath it; on the third day the waters drew away from the dry land, and from it the vast vegetable life which now exists made its appearance; that the fourth day was devoted to the apparition of the sun, the stars, the moon and the planets; that on the fifth day aquatic animals originated within the waters; and then on the sixth day the earth gave rise to our four-footed terrestrial creatures and to all varieties of terrestrial animals except birds, which had appeared on the preceding day; and finally, man appeared upon the earth, and the work of fashioning the universe was finished. John Milton, as I have said, leaves no doubt whatever as to how, in his judgment, these marvelous processes occurred. I doubt not that his immortal poem is familiar to all of you, but I should like to recall one passage to your minds in order that I may be justified in what I shall have to say. Regarding the perfectly concrete, definite conception which Milton had of what he thought had been the mode of origin of the animal world, he says:

> The sixth, and of creation last, arose
> With evening harps and matin; when God said,
> "Let the earth bring forth soul living in her kind,
> Cattle and creeping things, and beast of the earth,
> Each in their kind." The earth obey'd and straight
> Opening her fertile womb, teem'd at a birth
> Innumerous living creatures, perfect forms,
> Limb'd and full-grown; out of the ground up rose,
> As from his lair, the wild beast, where he wons
> In forest wild, in thicket, brake, or den;
> Among the trees in pairs they rose, and walk'd;
> The cattle in the fields and meadows green;
> Those rare and solitary, these in flocks
> Pasturing at once, and in broad herds upsprung.
> The grassy clods now calved; now half appears
> The tawny lion, pawing to get free
> His hinder parts, then springs, as broke from bonds,
> And rampant shakes his brinded mane; the ounce,
> The libbard, and the tiger, as the mole
> Rising, the crumbled earth above them threw
> In hillocks; the swift stag from under ground
> Bore up his branching head; scarce from his mould
> Behemoth, biggest born of earth, upheav'd
> His vastness; fleeced the flocks and bleating rose
> As plants; ambiguous between sea and land,
> The river-horse and scaly crocodile.
> At once came forth whatever creeps the ground,
> Insect or worm.

There is no doubt as to the meaning of that hypothesis, or as to what a man of Milton's genius expected would have been actually visible to one who could know and witness the process, the origination of living things as he describes it.

THE EVOLUTION HYPOTHESIS.

And then comes the third hypothesis, which is the hypothesis of evolution, and that supposes that at any given period in the past we should meet with a state of things more or less similar to the present, but less similar in proportion as we go back in time; that the physical form of the earth could be traced back in this way to a condition in which its parts were separated, as little more than a nebulous cloud making part of a whole in which we find the sun and the other planetary bodies also resolved; and that if we traced back the animal world and the vegetable world, we should find preceding what now exist animals and plants not identical with them, but like them, only increasing their differences as we go back in time, and at the same time becoming simpler and simpler, until finally we should arrive at that gelatinous mass which, so far as our present knowledge goes, is the common foundation of all life. The tendency of science is to justify the speculation that that also could be traced further back, perhaps to the general nebulous origin of matter.

The hypothesis of evolution supposes that in all this vast progression there would be no breach of continuity, no point at which we could say "this is a natural process" and "this is not a natural pro-

ocess," but that the whole might be strictly compared to that wonderful series of changes which may be seen going on every day under our eye, in virtue of which there arises out of that semi-fluid, homogeneous substance which we call an egg the complicated organization of one of the higher animals. That, in a few words, is what is meant by the hypothesis of evolution.

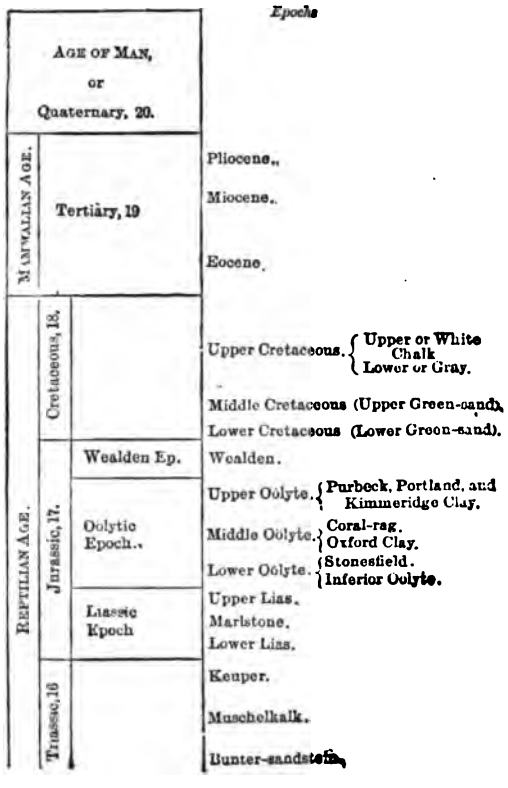
I have already suggested that in dealing with these three hypotheses, endeavoring to form a judgment as to which of them is the more worthy of belief, or whether none is worthy of belief, our condition of mind should be that suspension of judgment which is so difficult to all but trained minds—I have suggested that in dealing with these questions we should be indifferent to all *à priori* considerations. The question is a question of fact, historical fact. The universe has come into existence somehow or other, and the question is whether it came into existence in one fashion, or whether it came into existence in another; and as the essential preliminary to this consideration permit me to say two or three words as to the nature of historical evidence, and the kinds of historical evidence. The evidence as to the occurrence of any fact in past time is of one or two kinds, which, for convenience sake, I will speak of on the one hand as testimonial evidence, and on the other as circumstantial evidence. By testimonial evidence I mean human testimony; and by circumstantial evidence I mean evidence which is not human testimony. Let me illustrate by a familiar figure what I mean by these two kinds of evidence, and what is to be said respecting their value:

HUMAN AND CIRCUMSTANTIAL TESTIMONY COMPARED.

Suppose that a man tells you that he saw a person strike another and kill him: that is testimonial evidence of the fact of murder. But it is possible to have circumstantial evidence of the fact of murder. That is to say, you may find a man dying with a wound upon his head having exactly the form and character of the wound which is made by an ax, and with due precaution you may conclude with the utmost certainty that the man has been murdered—is dying in consequence of the violence inflicted by that implement. We are very much in the habit of considering circumstantial evidence as of less value than testimonial evidence, and it may be in many cases where the circumstances are not perfectly clear and perfectly intelligible that it is a dangerous and uncertain kind of evidence; but it must not be forgotten that in many cases it is quite as good as testimonial evidence, and that in many cases it is a great deal better than testimonial evidence. For example, take the case to which I referred just now. The circumstantial evidence is better and more convincing than the testimonial evidence, for it is impossible under the circumstances that I have mentioned to suppose that the man had met his death from any cause but the violent blow of the ax. The circumstantial evidence in favor of a murder having been committed, in that case is as complete and as convincing as evidence can be. It is evidence which is open to no doubt and no falsification. But the testimony of the witness is open to multitudinous doubts. He may have been mistaken. He may have been actuated by malice. It has constantly happened that even an accurate man has declared a thing has happened in some particular way, when a careful analysis of the circumstantial evidence has shown that it did not happen in that way, but in some other way.

Now we must turn to our three hypotheses. Let me first direct your attention to what is to be said about the hypothesis of the eternity of this state of things in which we now are. What will first strike you is that that is a hypothesis which, whether true or false, is not capable of verification by evidence; for in order to secure testimony to an eternity of duration you must have an eternity of witnesses or an infinity of circumstances, and neither of these are attainable. It is utterly impossible that such evidence should be carried beyond a certain point of time, and all that could be said at most would be that there was nothing to contradict the hypothesis. But when you look, not to the testimonial evidence—which might not be good for much in this case—but to the circumstantial evidence, then you find that this hypothesis is absolutely incompatible with that circumstantial evidence, and the latter is of so plain and so simple a character that it is impossible in any way to escape from the conclusions which it forces upon us.

THE ORDER OF NATURE.



THE ORDER OF NATURE. (Continued.) *Epochs,*

Carboniferous Age.	Permian.	15	Permian.
	Carboniferous.	14c	Upper Coal Measures.
		14b	Lower Coal Measures.
		14a	Millstone Grit.
	Subcarboniferous.	13b	Upper.
		13a	Lower.
Devonian Age, or Age of Fishes.	Catskill.	12	Catskill.
	Chemung.	11b	Chemung.
		11a	Portage.
	Hamilton.	10c	Genesee.
		10b	Hamilton.
		10a	Marcellus.
	Corniferous.	9c	Corniferous
		9b	Schoharie.
		9a	Cauda-Galli.
Silurian Age, or Age of Invertebrates.	Upper Silurian. Oriskany.	8	Oriskany.
	Lower Helderberg.	7	Lower Helderberg.
	Salina.	6	Salina.
	Niagara.	5c	Niagara.
		5b	Clinton.
		5a	Medina.
	Lower Silurian. Trenton.	4c	Cincinnati.
		4b	Utica.
		4a	Trenton.
	Canadian	3c	Chazy.
		3b	Quebec.
		3a	Calciferous.
	Primordial or Cambrian.	2b	Potsdam.
		2a	Acadian.
	Archæan.	1	Archæan.

You are, in fact, all aware that the crust of the earth, the superficial part of the earth, is not of a homogeneous character, but that it is made up of a number of beds of strata, the titles of the principal groups of which are placed upon that diagram—beds of sand, beds of stone, beds of clay, of slate, of granite, and of various other materials.

On further examination it is found that these beds of solid material are of exactly the same nature as those which are at present being formed under known conditions at the surface of the earth: that that chalk, for example, which forms a great part of the cretaceous formation in some parts of the world, that that chalk is identical in its physical and chemical characters, or practically so, with a substance which is now being formed at the bottom of the Atlantic Ocean, and covers an enormous area; that other bodies of rock are comparable with the sands which are being formed upon sea-shores, packed together, and so on. Thus it comes to be certain that each of these bodies of rock, of which a total of not less than 70,000 feet is known, that all these have been deposited and formed by natural agencies, either out of the waste and washing of the dry land, or else as the product of plants and animals. Now, these rocks or strata are full of the remains of animals and plants. Countless thousands of species of animals and plants as perfectly recognizable as those which you meet with in herbaria at the present day, as the shells and remains which you pick up upon the beach—countless thousands of species of these creatures have been imbedded in the sand or mud or limestone, just as they are being imbedded now. They furnish us with a record which cannot be subject to any misinterpretation, looking at it broadly, as to the kind of things that have lived upon the surface of the earth during the time that is registered by this great thickness of stratified rock. The most superficial study of these remains shows us that the animals and plants which live at the present time have had only a temporary duration; that you will find them and such as they are for the most part only in that uppermost strata here called post-tertiary. As you go back in time they become scantier, their places are taken by other forms more diversified, and in the jurassic and triassic you find yet others, different from the cretaceous or tertiary, and from those of the present day, and so on as you go further and further back. Why, then, the circumstantial evidence absolutely negatives the conception of the eternity of the present condition of things. We can say with certainty that such has not been the course of nature. We can say with certainty that the present condition of things has been for a comparatively short period, and that so far as animal and vegetable nature are concerned, that that has been preceded by a different condition of things. We can pursue this fact until we come to the lowest of stratified rocks, in which we lose the indications of life totally. The hypothesis of the eternity of the present condition of things may therefore be put out of court altogether.

MILTON'S HYPOTHESIS.

We now come to what I would call Milton's hypothesis—the hypothesis that the present condition of things has endured for a comparatively moderate time, and at the commencement of that time came into existence within the course of six days. I doubt not that it may have excited some surprise in your mind that I should have spoken of this as Milton's hypothesis rather than that I should choose the terms which are much more familiar to you, such as "the doctrine of cre-

ation," or "the Biblical doctrine," or "the doctrine of Moses," all of which terms as applied to the hypothesis to which I have just referred are certainly much more familiar to you than the title of the Miltonic hypothesis. But I have had what I cannot but think are very weighty reasons for taking the course which I have pursued. For example, I have discarded the title of the hypothesis of creation, because my present business is not with the question as to how nature has originated, as to the causes which have lead to her origination, but as to the manner and order of her origination. Our present inquiry is not why the objects which constitute nature came into existence, but when they came into existence, and in what order. This is a strictly historical question, a question as completely historical as that about the date at which the Angles and the Jutes invaded England. But the other question about creation is a philosophical question, and one which cannot be solved or approached or touched by the historical method. What we want to know is whether there is evidence in the facts, so far as they are known, that things arose in the way described by Milton, or not; and when that question is settled, it will be time enough to inquire as to why they arose.

In the second place, I have not spoken of it as the Biblical hypothesis. It is quite true that persons as diverse in their general views as Milton the Protestant and the Jesuit Father Suarez agree in giving the 1st chapter of Genesis the interpretation as adopted by Milton. It is quite true that that interpretation, unless I mistake, is that which has been instilled into every one of us in our childhood; but I do not for one moment venture to say that it could properly be called the Biblical doctrine. In the first place, it is not my business to say what the Hebrew text contains, and what it does not; and in the second place, were I to say that this was the Biblical hypothesis, I should be met by the authority of many eminent scholars, to say nothing of men of science, who in recent times have absolutely denied that this doctrine is to be found in Genesis at all. If we are to listen to them we must believe that what seem so clearly defined as days of creation—as if very great pains had been taken that there should be no mistake—that these are not days at all, but periods that we may make just as long as convenience requires. We are also to understand that it is consistent with that phraseology to believe that plants and animals may have been evolved by natural processes, lasting for millions of years, out of similar rudiments. A person who is not a Hebrew scholar can only stand by and admire the marvelous flexibility of a language which admits of such diverse interpretations. [Applause and laughter.]

PROF. HUXLEY NOT AN AUTHORITY ON THE BIBLE.

Assuredly in the face of such contradictory authority upon matters upon which one is competent to form no judgment, he will abstain from giving any opinion, as I do; and in the third place, I have carefully abstained from speaking of this as a Mosaic doctrine because we are now assured upon the authority of the highest critics, and even of dignitaries in the Church, that there is no evidence whatever that Moses ever wrote this chapter, or knew anything about it. I don't say—I give no opinion—it would be an impertinence upon my part to volunteer an opinion upon such a subject. But that being the state of opinion among the scholars and the clergy, it is well for us the laity, who stand outside, to avoid entangling ourselves in such a vexed question. So as there is a doubt, and as happily Milton leaves us no conceivable ambiguity as to what he means, I will continue to speak of it as the Miltonian hypothesis. [Applause.]

Now then we have to test that hypothesis. For my part I have no prejudice one way or the other. If there is evidence in favor of this view I have no sort of theoretical difficulties in the way of accepting it, but there must be evidence. We men of science get an awkward habit—no I won't call it that, for it is a valuable habit—of reasoning so that we believe nothing unless there is evidence for it, and we have a way of looking upon belief which is not based upon evidence not only as illogical, but as immoral. We will, if you please, test this view in the light of facts, for by what I have said you will understand that I don't propose to discuss the question of what testimonial evidence is to be adduced in favor of this view. If those whose business it is to judge are not united as to the authenticity of the document or the fact as to who it is bears witness, the discussion of testimonial evidence is superfluous. But one regards this less because the circumstantial evidence, if carefully considered, brings him to the conclusion that the theory is inadequate altogether, and cannot be adduced. And the considerations upon which I base that conclusion are of the simplest possible character. Whatever the flexibility of interpretation of Milton's views, it is quite impossible to deny that the kernel of the whole matter is a statement as to a certain order or succession of living forms. It is stated that plants, for example, made their appearance upon the third day, and not before. And you will understand that by plants was meant the plants which now live—the trees and shrubs which we now have. It is one of two things—either the existing plants have been the result of a separate origination of which we have no record for supposition, or else they have arisen by that dreaded process of evolution from the original stock. And in the second place it is clear that there was no animal life before the fourth day, and then on the fourth day marine animals and birds appeared. And it is further clear that terrestrial life made its appearance upon the sixth day and not before. Hence it follows that if in this record, if in this large mass of circumstantial evidence as to what really has happened in the past history of the globe—if in that we find down to a certain point indications of the existence of terrestrial animals, it is perfectly certain that all that has taken place since that time must be referred to the sixth day. In this great carboniferous formation from whence America has

derived so vast a proportion of her actual and potential wealth, in that formation and in the beds of coal which are formed from the vegetation of that period, we find abundant evidence of the existence of terrestrial animals. They have been described not only by European naturalists but by your own naturalists. There are to be found in the coal of your own coal fields numerous insects allied to our cockroaches. There are to be found there scorpions of large size, and so similar to existing scorpions that it requires the practiced eye of the naturalist to distinguish them—and even spiders. Inasmuch as these things can be proved to have had full life in the carboniferous epoch, it is perfectly clear that, if the Miltonic account is correct, those huge rocks extending from the middle of the palæozoic formations must belong to the day or period which is termed by Milton the sixth day of the creation. But further, it is expressly stated that aquatic animals took their origin upon the fifth day, and did not exist before, hence all formations in which aquatic animals can be proved to exist and therefore lived at the time these formations were deposited, all those must have been deposited during the time since the period which Milton speaks of as the fifth day. But there is absolutely no fossiliferous rock in which you do not find the remains of marine animals. The lowest forms of life in the silurian are marine animals, and if the view which is entertained by Principal Dawson and Dr. Carpenter of the eozoön be correct, if it is true that animal remains exist at a period as far antecedent to the deposit in the coal as the coal is from us, at the very bottom in a series of stratified rock, in what are called the Laurentian strata, it follows plainly enough from this that the whole series of stratified rocks, if they are to be brought into harmony with Milton at all, must be referred to the sixth day, and we cannot hope to find the slightest trace of the work of the other days in our stratified formations. When one comes to consider this, one sees how absolutely futile are the attempts that have been made to run a parallel between the stratified rocks as we know them and the account which Milton gives of it. The whole series of stratified rocks must be referred to the two last periods. It is of course futile to look in carboniferous rocks in the miocene for animals which according to the hypothesis were of the sixth day. Not only is there this objection to any attempt to run a parallel between the Miltonic account and the actual facts, but there is further difficulty. In the Miltonic account the order in which animals should have made their appearance in the stratified rock would be this: Fishes, including the great whale, and birds; after that all varieties of terrestrial animals. Nothing could be further from the facts as we find them. As a matter of fact we know of not the slightest evidence of the existence of birds before what are there indicated [pointing to the chart] as the jurassic, and perhaps the triassic formations.

OTHER FAILURES OF THE MILTONIC THEORY.

If there were any parallel between the Miltonic account and the circumstantial evidence, we ought to have abundant evidence in the devonian, the silurian, and the carboniferous rocks. I need not tell you that this is not the case, and that not a trace of birds makes its appearance until the far later period which I have mentioned.

And again, if it be true that all varieties of fishes and the great whales and the like made their appearance on the fifth day, then we ought to find the remains of these things in the older rocks—in those which preceded the carboniferous epoch. Fishes, if if true, we find, and numerous ones; but the great whales are absent, and the fishes are not such as now live. Not one solitary species of fish now in existence is to be found there, and hence you are introduced again to the difficulty, to the dilemma, that either the creatures which were created then, which came into existence the sixth day, were not those which are found at present, or are not the direct and immediate predecessors of those which now exist; but in that case you must either have had a fresh species of which nothing has been said, or else the whole story must be given up as absolutely devoid of any circumstantial evidence.

I have grouped before you in a few words some little time ago a statement of the sum and substance of Milton's hypothesis. Let me try now to put before you in a few words the sum and substance of the circumstantial evidence as to the past history of the earth which is written without the possibility of mistake, with no chance of error in the stratified rocks. What we find is that that great series of formations represents a period of time of which our human chronologies hardly afford us a unit of measure. I will not pretend to say how we ought to measure this time, in millions or in billions of years. Happily for my purpose and my argument, that is wholly unessential. But that the time was enormous, was vast, there is no sort of question.

We find written upon this record, and as resulting from the simplest methods of interpretation, the conviction that all that is now dry land has once been at the bottom of the waters. If I leave out of view certain patches of metamorphosed rocks, certain volcanic products, it is perfectly certain that at a comparatively recent period of the world's history that epoch which is written on the chart as the cretaceous epoch —it is perfectly certain that at that time none of the great physical features which at present mark the surface of the globe existed. It is certain that the Rocky Mountains were not. It is certain that the Himalaya Mountains were not. It is certain that the Alps and the Pyrenees had no existence. The evidence of the simplest possible character is simply this: We find raised up on the crags of these mountains, elevated by the forces of upheaval which have given rise to them, masses of cretaceous

rock which formed the bottom of the sea before those mountains existed. It is therefore perfectly clear that the elementary forces which gave rise to those mountains are subsequent to the cretaceous epoch; that the mountains themselves are largely made up of the materials deposited in the sea which once occupied their place. We meet as we go back in time with constant alternations of sea and land, of estuary and open ocean, and in correspondence with these alterations we meet with changes in the fauna and flora of the kind I have stated.

But none of these gives us any right to believe, no inspection of these changes gives us the slightest right to believe, that there has been any discontinuity in natural processes. There is no trace of cataclysm, of great sweeping deluge, of sudden destruction of organic life. The appearances which were formerly interpreted in that way have all been shown to be delusive as our knowledge has increased and as the blanks between the different formations have been filled up. It can now be shown that there is no absolute break between formation and formation, that there has been no sudden disappearance of all the forms of life at one time and replacement by another, but that everything has gone on slowly and gradually, that one form has died out and another has taken its place, and that thus by slow degrees one fauna has been replaced by another. So that within the whole of the immense period indicated by these stratified rocks, there is assuredly—leaving evolution out of the question altogether—not the slightest trace of any break in the uniformity of nature's operations, not a shadow of indication that events have followed in other than their natural and orderly sequence.

That, I say, is the most natural teaching of the circumstantial evidence contained in the stratified rock. I leave you to consider how far by any ingenuity of interpretation, by any stretching of the meaning of language, this evidence can be brought into the smallest similarity with that view which I have put before you as the Miltonic doctrine.

There remains the third hypothesis—what I have spoken of as the hypothesis of evolution; and I propose that in lectures to come we shall consider that as carefully as we have considered the other two hypotheses. I need not say that it is quite hopeless to look for testimonial evidence of evolution. The very nature of the case precludes the possibility of such evidence. Our important inquiry is, what foundation circumstantial evidence lends to that hypothesis, or whether it lends any, or whether it controverts it; and I shall deal with the matter entirely as a question of history. I shall not indulge in the discussion of any speculative probabilities. I shall not attempt to show that nature is unintelligible unless we adopt some such hypothesis—for anything I know about it, it is the nature of Nature. She has often been puzzling, and I have no reason to suppose she is bound to fit herself to our notions; but I shall deal with the matter entirely from the point of view of history, and I shall place before you three kinds of evidence entirely based upon what we know of the forms of animal life which are contained in the series of stratified rock. I shall endeavor to show you that there is one kind of evidence which is neutral, which neither helps evolution nor is inconsistent with it. I shall then endeavor to show you that there is a second kind of evidence which indicates a strong probability in favor of evolution, but does not prove it; and, lastly, I shall endeavor to show that there is a third kind of evidence which, being as complete as any evidence which we can hope to obtain upon such a subject, and being wholly and entirely in favor of evolution, may be fairly called demonstrative evidence of its having occurred.

But these matters, ladies and gentlemen, I propose to deal with in the next two lectures.

EVIDENCES OF EVOLUTION—II.

PROF. HUXLEY'S SECOND LECTURE IN NEW-YORK.

THE THEORY TESTED BY FACTS.

THREE CLASSES OF EVIDENCE BEARING ON THE POINT—MEANING OF THE FACT THAT CERTAIN VERY ANCIENT SPECIES HAVE NOT CHANGED—PROBABILITY OF GAPS IN THE HISTORY AS SHOWN BY FOSSILS—CERTAIN GAPS FILLED BY THE DISCOVERIES OF PROF. MARSH—BIRDS THAT HAVE TEETH—ANIMALS HALF WAY BETWEEN BIRDS AND REPTILES.

Prof. Huxley's experience in his first lecture at Chickering Hall of the difficulty of making himself heard while the people were entering and finding their seats, was doubtless the occasion of his delay of ten minutes on the evening of Sept. 20 in coming on the stage. When he entered, nearly every seat was occupied.

Behind the speaker a large frame had been provided, on which were hung diagrams illustrative of the subjects to be treated in the lecture. These diagrams had been prepared with great care and accuracy under the supervision of Prof. Marsh, and they were so plainly lettered that there could be no possibility of mistaking their titles. Several of these diagrams illustrate Prof. Marsh's most recent discoveries, and will be quite new to the general public. The engravings will give a fair notion of the drawings.

THE LECTURE.

LADIES AND GENTLEMEN: In my lecture on Monday night I pointed out to you that there are three hypotheses which may be entertained, and which have been entertained, respecting the past history of life upon the globe. According to the first of these hypotheses, life, such as we now know it, has existed from all eternity upon this earth. We tested that hypothesis by the circumstantial evidence, as I called it, which is furnished by the fossil remains contained in the earth's crust, and we found that it was obviously untenable. I then proceeded to consider the second hypothesis, which I termed the Miltonic hypothesis, not because it is of any particular consequence to me whether John Milton seriously entertained it or not, but because it is stated in a clear and unmistakable manner in his great poem. I pointed out to you that the evidence at our command as completely and fully negatives that hypothesis as it did the preceding one. And I confess that I had too much respect for your intelligence to think it necessary to add that that negation was equally strong and equally valid whatever the source from which that hypothesis might be derived, or whatever the authority it might be supported by.

THE EVIDENCE DIVIDED INTO THREE CLASSES.

I further stated that according to the hypothesis of evolution the existing state of things was at the last term of a long series of antecedent states, which, when traced back, would be found to show no interruption and no breach of continuity. I propose in this and a following lecture to show that, no less rigorously, by the evidence at command, and to inquire how far that evidence could be said to be indifferent to it, how far it could be said to be favorable to it, and finally, how far it could be said to be demonstrative. From almost the origin of these discussions upon the existing condition—and the causes which have led to it—of the animal and vegetable world, an argument has been put forward as an objection to evolution, which we shall have to consider very seriously. I think that that argument was first clearly stated by Cuvier in his opposition to the doctrines propounded by his great cotemporary, Lamarck. At that time the French expedition to Egypt had called the attention of learned men to the wonderful stores of antiquities in that country, and there had been brought back to France numerous mummified corpses of animals which the ancient Egyptians revered and preserved, the date of which at a reasonable computation—a computation, I may say, which has been verified by all subsequent researches—cannot be placed at less than 3,000 or 4,000 years before the time at which they were thus brought to light. Cuvier endeavored to ascertain by a very just and proper method what foundation there was for the belief in a gradual and progressive change of animals, by comparing the skeletons and all accessible parts of these animals, such as crocodiles, birds, dogs, cats, and the like, with those which are now found living in Egypt, and he came to the conclusion—a conclusion which has been verified by all subsequent research—that no appreciable change had taken place in the animals which inhabited Egypt. And he drew thence the conclusion, and a hasty one, that the evidence of such fact was altogether against the doctrine of evolution.

AN ILLUSTRATION FROM NIAGARA.

The progress of research since Cuvier's time has furnished far stronger cases than those which he drew from the mummified bodies of Egyptian animals. A remarkable case is to be found in your own country in the neighborhood of the magnificent Falls of Niagara. In the immediate vicinity of the whirlpool, and again upon Goat Island, in the superficial deposits which cover the surface of the soil of the rock in those regions, there are found remains of animals in perfect preservation—shells belonging to exactly the same forms as at present inhabit the still waters of Lake Erie. It is evident here from the formation of the country that these animal remains were deposited in the beds in which they are found, at the time at which the lake extended over the region in which they are found, and that involves the necessity that they existed and lived and died before the falls had cut their way back through the gorge of Niagara; and indeed it is possible to determine that at that time the falls of Niagara must have been at least six miles further down the river than they are at present. Many computations have been made of the rate at which Niagara is thus cutting its way back. Those computations have varied greatly, but I believe I am speaking within the bounds of prudence, if I assume that at its greatest rate of cutting back the falls of Niagara have not retreated at a greater pace than about a foot a year. Six miles, speaking roughly, are 30,000 feet; 30,000 feet at a foot a year are 30,000 years, and we are fairly justified in concluding that no less a period than that has passed since these shell-fish, whose remains are left in the beds to which we have referred, were deposited. Admit that it is true that for that immense period of time no change has taken place in these animals, there are still stronger evidences on this point even than this. As we work our way through the great series of the tertiary formation, we find species of animals identical with those which live at the present day, diminishing in numbers it is true, but still existing in a certain number in the oldest of the tertiary rocks. And not only so, but when we examine the rocks of the cretaceous epoch itself, we find the remains of some animals which the closest scrutiny cannot show to be in any respect different from those which live at the present time. That is the case with one of the lamp shells, the terebratula, which is found in the chalk, and which has continued as it was found, or with insignificant variation, through to the present day. Such is the case with the globigerina, the skeletons of which aggregated together form the great mass of our chalk in England. That globigerina can be traced down to the globigerinæ, which live at the surface of our great oceans, and the remains of which falling to the bottom of the sea

give rise to a chalk material. So that it must be admitted that certain species of creatures living at the present day show no sign of modification or transformation as great as that which carries us back to the period of chalk; and we find some groups or species so closely allied together that it needs the eye of a naturalist to distinguish them one from another. If we pay attention to these, we find that a vastly greater period must be allotted in some cases to these persistent forms. In chalk itself, for example, there is the fish belonging to the highest group of fishes and the most differentiated of osseous fishes, which goes by the name of Beryx. That fish is one of the most beautiful of fossils found in our English chalk. It is an anatomical study, so far as the hard part is concerned, almost as well as if it were a recent fish. We find that that fish is represented at the present day by very closely allied species which are living in the Pacific and Atlantic Oceans. We may go still further back about this evidence of closely allied species, and we find, for example, as I mentioned to you in my first lecture, that the coal deposit in Europe contains the remains of scorpions in an admirable state of preservation, and those scorpions are hardly distinguishable—I do not mean to say that they are not distinguishable, but they require close scrutiny to distinguish them—from the scorpions which exist at the present day.

OTHER INSTANCES OF PERSISTENT FORM.

More than that. At the very bottom of the Silurian series, in what is by some authorities termed the Cambrian formation, where all signs appear to be dying out—even there, among the few and scanty animal remains which exist, we find species of molluscous animals which are so closely allied to existing forms that at one time they were grouped under the same generic name. I refer to the well-known *Lingula* of the *Lingula* flags. It was subsequently, in consequence of some slight differences, placed in the new genus *Lingulella*. Practically it belongs to the same great generic group as the *Lingula*, which you will find at the present day upon the shores of Australia. And the same thing is exemplified if we turn to certain great periods of the earth's history—as, for example, throughout the whole of the mesozoic period. There are groups of reptiles which begin shortly after the commencement of this period, as the *Ichthyosauria* and the *Plesiosauria*, and they abound in vast numbers. They disappear with the chalk, and throughout the whole of that great series of rock they present no important modification. Facts of this kind are undoubtedly fatal to any form of the doctrine of evolution which necessitates the supposition that there is an intrinsic necessity on the part of animal forms which once come into existence to undergo modification; and they are still more distinctly opposed to any view which should lead to the belief that the modification in different types of animal or vegetable life goes on equally and evenly. The facts, as I have placed them before you, would obviously contradict directly any such form of the hypothesis of evolution as laid down in these two postulates.

Now the service that has been rendered by Mr. Darwin to the doctrine of evolution in general is this: that he has shown that there are two great factors in the process of evolution, and one of them is the tendency to vary, the existence of which may be proved by observation in all living forms; the other is the influence of surrounding conditions upon what I may call the parent form and the variations which are thus evolved from it. The cause of that production of variations is a matter not at all properly understood at present. Whether it depends upon some intricate machinery—if I may use the phrase—of the animal form itself, or whether it arises through the influence of conditions upon that form, is not certain, and the question may for the present be left open. But the important point is the tendency to the production of variations; then whether those variations shall survive and supplant the parent, or whether the parent form shall survive and supplant the variations, is a matter which depends entirely on surrounding conditions. If the surrounding conditions are such that the parent form is more competent to deal with them and flourish in them than the derived forms, then in the struggle for existence the parent form will maintain itself and the derived forms will be exterminated. But if, on the contrary, the conditions are such as to be better for the derived than for the parent form, the parent form will be extirpated and the derived form will take its place.

In the first case there will be no progression, no advance of type, through any imaginable series of ages; in the second place, there will be modification and change of form, and thus we see that the immense amount of evidence brought to show that things do in this way take place in nature, puts us in such a place that the existence of these persistent types of life is no obstacle in the way of the theory of evolution at all. Take the case of these scorpions to which I have just referred. No doubt since the carboniferous epoch conditions have existed such as existed then when scorpions flourished, in which they find themselves better off, more competent to deal with the difficulties in their way than any kind of variation from the scorpion type; and for that reason the scorpion has persisted and has not been supplanted by any other form. And there is no reason in the nature of things why, as long as this world exists, if there be conditions more favorable to scorpions than any variation which may arise from them, these forms of life should not persist.

IMPERFECTION OF THE GEOLOGICAL RECORD.

Therefore, this objection is no objection at all. The facts of this character—and they are numerous—belong to that class of evidence which I have called indifferent. That is to say, they may be no direct support to the doctrine of evolution, but they are perfectly capable of being interpreted in consistency with it. There is another order of facts of the same kind, and susceptible of the same interpretation. The great group of *Lizards*, which abound so much at the present day, extends through the

whole series of formations as far back as what is called the Permian epoch, which is represented by the strata lying just above the coal. These Permian lizards differ astonishingly little—in some respects—from the lizards which exist at the present day. Comparing the amount of difference between these Permian lizards and the lizards of the present day with the prodigious lapse of time between the Permian epoch and the present age, it may be said that there has been no appreciable change.

But the moment you carry the researches further back in time you find no trace whatever of lizards nor of any true reptile whatever in the whole mass of formations beneath the Permian. Now it is perfectly clear that if our existing palæontological collections, our existing specimens from stratified rock, exhaust the whole series of events which have ever taken place upon the surface of the globe, such a fact as this directly contravenes the whole theory of evolution, because that postulates that the existence of every form must have been preceded by that of some form comparatively little different from it. Here, however, we have taken in consideration that important fact so well insisted upon by Lyell and Darwin—the imperfection of the geological record. It can be demonstrated as a matter of fact that the geological record must be incomplete, that it can only preserve remains found in certain favorable localities and under particular conditions; that it must be destroyed by processes of denudation, and obliterated by processes of metamorphsis—by which I mean that beds of rock of any thickness crammed full of organic remains may yet, either by the percolation of water through them or the influence of subterranean heat (if they descend far enough toward the center of the earth), lose all trace of these remains and present the appearance of beds of rock formed under conditions in which there was no trace of living forms. Such metamorphic rocks occur in formations of all ages, and we know with perfect certainty when they do appear that they have contained organic remains, and that those remains have been absolutely obliterated.

One of the most striking proofs with which I am acquainted of the defects of the geological record—and I insist upon it the more because those who have not attended to these matters are apt to say to themselves, "It is all very well, but when you get into difficulty with your theory of evolution you appeal to the incompleteness and the imperfection of the geological record," and I want to make it perfectly clear to you that that imperfection is a vast fact which must be taken into account with all our speculations or we shall constantly be going wrong.

TRACKS OF THE BRONTOZOUM.

You will all see that singular series of tracks which is copied to its natural size in the large diagram hanging up here, which I owe to the kindness of my friend Prof. Marsh, with whom I had the opportunity recently of visiting the precise locality in Massachusetts in which these tracks occur. I am, therefore, able to give you my own testimony, if needed, that they accurately represent the state of things which we saw. The valley of the Connecticut is classical ground for the geologist. It contains great beds of sandstone, covering many square miles, and which present this peculiarity, that they have evidently formed a part of an ancient sea shore, or, it may be, lake shore, and that they have been sufficiently soft for a certain period of time to receive the impressions of whatever animals walked over them, and to preserve them afterward in exactly the same way, as such impressions are at this very moment preserved on the shores of the Bay of Fundy and elsewhere. We have there the tracks of some gigantic, animal (pointing to the diagram) which walked on its hind legs. You see the series of marks made alternately by the right foot and by the left foot; so that from one impression to the other of the three-toed feet on the same side is one stride, and that stride, as we measured it, is six feet nine inches. I leave you, therefore, to form an impression of the magnitude of the creature which must have walked along the ancient shore, and which made these impressions.

Now, of such impressions there are untold thousands upon these shores. Fifty or sixty different kinds have been discovered, and they cover vast areas. But up to this present time not a bone, not a fragment, of any one of the great creatures which certainly made these impressions has been found; and the only skeleton which has been met with in all these deposits, to the present day—though they have been carefully hunted over—is one fragmentary skeleton of one of the smaller forms. What has become of all these bones? You see we are not dealing with little creatures, but animals that make a step of six feet nine inches; and their remains must have been left somewhere. The probability is that they have been dissolved away, and absolutely lost.

I have had occasion to work at series of fossil remains of which there was nothing whatever except the casts of the bones, the solid material of the bone having been dissolved out by percolating water. It was a chance in this case that the sandstone happened to be of such a constitution as to set, and to allow the bones to be afterward dissolved out.

Had that constitution been other than what it was, the bones would have been dissolved, the beds of sandstone would have fallen together, become one mass, and not the slightest indication that the animal had existed would have been discovered.

I know of no more striking evidence than this fact affords from which it may be concluded, in the absence of organic remains, that such animals did exist. I believe that having the right understanding of the doctrine of evolution on the one hand, and having a just estimation of the importance of the imperfection of the geological record on the other, would remove all difficulty from the kind of evi

dence to which I have thus adverted, and this appreciation allows us to believe that all such cases are examples of what I may here call, and have hitherto designated, negative or indifferent evidence—that is to say, they in no way directly advance the theory of evolution, but they are no obstacle in the way of our belief in the doctrine.

EVIDENCE OF INTERMEDIATE FORMS.

I now pass on to the consideration of those cases which are not—for the reason which I will point out to you by and by—demonstrative of the truth of evolution, but which are such as must exist if evolution be true, and which therefore are upon the whole strongly in favor of the doctrine. If the doctrine of evolution be true, it follows that animals and plants, however diverse they may be—however diverse the different groups of animals, however diverse the different groups of plants—must have all been connected together by gradational forms; so that, from the highest animals, whatever they may be, down to the lowest speck of gelatinous matter in which life can be manifested, there must be a sure and progressive body of evidence—a series of gradations by which you could pass from one end of the series to the other. Undoubtedly that is a necessary postulate of the doctrine of evolution. But when we look upon animated nature as it at present exists, we find something totally different from this. We find that animals and plants fall into groups, the different members of which are pretty closely allied together, but which are separated by great breaks at intervals from other groups. And I cannot at present find any intermediate forms which bridge over these gaps or intervals. To illustrate what I mean: Let me call your attention to those vertebrate animals which are more familiar to you, such as mammals and birds and reptiles. At the present day these groups of animals are perfectly well defined from one another. We know of no animal now living which in any sense is intermediate between the mammal and the bird, or between the bird and reptile. but, on the contrary, there are actually some very distinct and anatomical peculiarities, well defined marks, by which the mammal is separated from the bird, and the bird from the reptile. The distinctions are apparent and striking if you compare together the different divisions of these great groups. At the present day there are numerous forms of what we may call broadly the pig tribe, and many varieties of ruminants. These latter have their definite characteristics, and the former have their distinguishing peculiarities. But there is nothing that comes between these ruminants and the other tribe—the pig tribe. The two are distinct. So also is this the case between the groups of another class.—the reptiles. We have crocodiles, lizards, snakes, turtles, and tortoises, and yet there is nothing—no connecting link—between the crocodile and lizard, or between the lizard and snake, or between the snake and the crocodile, or between any two of these groups. They are separated by absolute breaks. If then it could be shown that this state of things was from the beginning—had always existed—it would be fatal to the doctrine of evolution. If the intermediate gradations which the doctrine of evolution postulates must have existed between these groups—if they are not to be found anywhere in the records of the past history of the globe—all that is so much a strong and weighty argument against evolution. While, on the other hand, if such intermediate forms are to be found, that is so much to the good of evolution, although for the reason which I will put before you by and by, we must be cautious in assuming such facts as proofs of the theory.

It is a very remarkable fact that, from the first commencement of the serious study of palæontology, from the time in fact when Cuvier made his brilliant researches in respect to animals found in the quarries of Montmartre—from that time palæontology has shown what she was going to do in this matter, and what kind of evidence it lay in her power to produce. I said just now that at the present day the group of pig-like animals and the group of ruminants are entirely distinct; but one of the first of Cuvier's discoveries was an animal which he called the Anoplotherium, and which he showed to be, in a great many important respects, intermediate in its character between the pigs on the one hand and the ruminants on the other; that in fact research into the history of the past did so far—and to the extent which Cuvier indicated—tend to fill up the breach between the group of ruminants and the group of pigs.

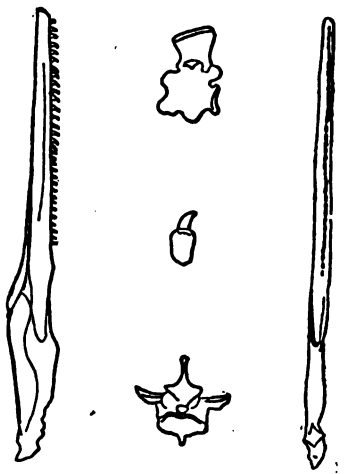
BIRDS AND REPTILES.

All subsequent research has also tended in this direction; and at the present day the investigations of such men as Rütemeyer and Gaudry have tended to fill up and connect, more and more, the gaps in our existing series of mammals. But I think it may have an especial interest if—instead of dealing with these cases, which would require a great deal of tedious osteological detail to explain—if I take the case of birds and reptiles—which groups, at this present day, are so clearly distinguished from one another that there are perhaps no classes of animals which in popular apprehension are more completely separated. Birds, as you are aware, are covered with feathers: they are provided with wings; they are specially and peculiarly modified as to their anterior extremities; and they walk perpendicularly upon two legs; and those limbs, when they are considered anatomically, present a great number of exceedingly remarkable peculiarities, to which I may have occasion to advert incidentally as I go on, but which are not met with even approximately in the existing form of reptiles. On the other hand, reptiles, if they have a covering at all, have a covering of scales or bony plates. They possess no wings; they are not volatile, and they have no such modification of the limbs as we find in birds. It is impossible to imagine any two groups apparently more definitely and distinctly separated. As we trace the history of birds back in time we find their remains abundant in the tertiary rocks throughout their whole extent, but, so far as anything is known, birds of the tertiary

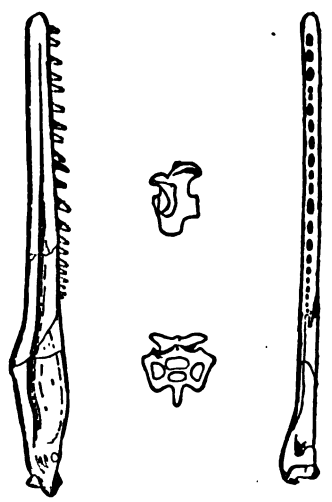
rocks, though retaining the same essential character as the birds of the present day—that is to say, the tertiary bird coming within the definition of our existing birds—are as much separated from reptiles as our existing birds are. A few years ago no remains of birds had been found below the tertiary rocks, and I am not sure but that some persons were prepared to demonstrate that they could not have existed at an earlier period. But in the last few years such remains have been discovered in England, though unfortunately in a very imperfect condition. In your country the development of cretaceous rocks is enormous, and the conditions under which the later cretaceous strata have been deposited are favorable for the preservation of organic remains in a perfect condition, and the researches full of labor and toil which have been carried on by Prof. Marsh in these Western cretaceous rocks have rewarded him with the discovery of forms of birds of which we had hitherto no conception. By his kindness, I am enabled to place before you a restoration of one of these extraordinary birds, every part of which can be thoroughly proved and justified. The remains exist in the greatest beauty in his collection.

HESPERORNIS REGALIS (*Marsh*)

A bird about six feet high, a large bird, existed during the later cretaceous epoch, and which in a great many respects is astonishingly like an existing diver or grebe, so like it indeed, that had this skeleton been found in a museum, I suppose—if the head had not been known—it would have been placed in the same general group as the divers and grebes of the present day. But this bird differs from all existing birds, and so far resembles reptiles in the one important particular that it is provided with teeth. These long jaws [referring to the picture behind him] are beset with teeth, as in this diagram. Here is one of the teeth, and in this particular it differs entirely from any existing bird, and it is in view of the characteristics of this Hesperornis that we are obliged to modify the definition of the classes of birds and reptiles. Before the production of a creature such as this, it might have been said that a bird had such and such characteristics, among which were an absence of teeth, but the discovery of a bird that had teeth shows at once that there were ancient birds that in that particular respect approached reptiles more nearly than any existing bird does.



HESPERORNIS REGALIS (*Marsh*)



ICHTHYORNIS DISPAR (*Marsh*)

The same rocks have yielded another bird (Ichthyornis) which also has teeth in its jaws, the teeth in this case being situated in distinct sockets, while those of the swimming bird (Hesperornis) differ essentially, being in grooves. The latter also had smaller wings than those of a flying bird. Ichthyornis also differed in the fact that the joints of its backbone—its vertebræ—had not the peculiar character that existing birds have, but were concave at each end. This discovery leads us to make another modification in the character of the divisions of birds, showing that they are not so far off from reptiles. We know nothing whatever of birds older than these until we come down to the Jurassic period, and from that period

we know a single bird which was first made known by the finding of a fossil feather. It was thought wonderful that such a perishable thing as a feather should be discovered and nothing more, and so it was, and for a long time nothing was known of this bird except its feather. But by and by one solitary specimen was discovered, which is now in the British Museum. That solitary specimen is unfortunately devoid of its head, but there is this wonderful peculiarity about the creature, that while so far as its feet are known it has all the characters of a bird, all those peculiarities by which a bird is distinguished from a reptile, when we examine the vertebral column, it is unlike a bird and like a reptile. It had a long tail with a fringe of feathers on each side. We find that division of the wing which corresponds with the hand, and the wing itself differing in some very remarkable respects from the structure it presents in a true bird. In a true bird the wing answers to these three fingers—the thumb and next two fingers of my hand—and these bones behind the fingers which I am touching are all fused together in one mass—anchylosed, or coössified, as we say—and the whole apparatus except the thumb is bound up in a great sheath of integument, which supports the feathers of the wing; the edge of the arm, &c., carrying the feathers. It is in that way that the bird's wing becomes an instrument of flight. In this bird—the Archæopteryx—the upper arm is like that of a bird; these two fore-arm bones are more or less like that of a bird, but these fingers are not bound together—they are free, and they are all terminated by strong claws not like a bird, but evidently by such a structure as reptiles possess, so that in this single Archæopteryx you have an animal which becomes to a certain extent the midway place between a bird and a reptile. It is a bird so far as its hand and limbs are concerned—it is essentially and thoroughly a bird in the fact that it possesses feathers, but it is much more properly a reptile in the fact that its anterior limb has separate bones resembling the fore limb of a reptile. All these cases, so far as they go, you will observe, are in favor of evolution to this extent, that they show that in former periods of the world's history there were creatures existing which overstep the bounds of all existing classes and groups and tend to fill up the intervals which at present exist between them. But we can go further than this. It is possible to fill up the interval between birds and reptiles in a much more striking manner. I don't say that this is to be done by looking upon what are called the Pterodactyls as the intermediate form between birds and reptiles. Throughout the whole series of the mesozoic rocks we meet with some exceedingly remarkable flying creatures, some of which attain a great size, their wings having a span of eighteen or twenty feet or more, and these are known as Pterosauria, or Pterodactyls. We find these with a bird-like head and neck, with a vertebral column sometimes terminated in a short tail, and sometimes in a long tail, and in which the bones of the skeleton present one of the peculiarities which we often consider are most characteristic of birds—that of being excavated and filled with air, or having pneumatic cavities, which make the creature specifically light in its flight.

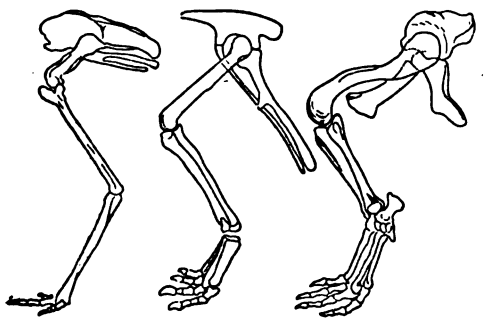
PTERODACTYLUS SPECTABILIS (*Von Meyer*)

Like a bird, this creature has a largish breast-bone, with a crest upon it and a shoulder-girdle much like a bird; but from that point onward, so far as I can see, special, particular resemblances end, and a careful examination of the fore limbs shows you that they are not birds' wings; they are something totally different from a bird's wings. And then, again (pointing to chart), those are not a bird's posterior extremities, but are rather what is termed reptilian. You will observe that the fore-arm presents nothing that I need dwell upon, but the bones of the hand are very wonderful. There are four fingers represented. These four fingers are large, and three of them, these, which answer to these three in my hands, are terminated by claws, while the fourth is enormously prolonged into a great jointed style. Nothing could be more unlike a bird's claw than this is. You see at once from what I have stated about a bird's wing that there could be nothing more unlike a bird's wing than this is. It was concluded by general reasoning that this finger was made to support a great web like a bat's wing. Specimens now exist showing that this was really the case, that this creature was devoid of feathers, but the fingers supported a vast web like a bat's wing. We see this ancient reptile floated by a similar method, so that the Pterodactyl, although it is a flying reptile, although it presents some points of similarity to birds, yet is so different from them that I do not think that we have any right to regard it as one of the forms intermediate between the reptile and the bird.

DINOSAURS TRUE INTERMEDIATE FORMS.

Such intermediate forms are to be found, however, by looking in a different direction. Through the whole series of mesozoic rocks there occur reptiles, some of which are of gigantic dimensions; in fact, they are

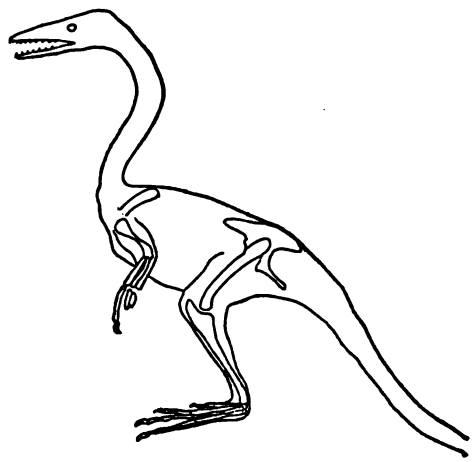
reckoned among the largest of terrestrial animals. Some of them are 40 and 50, possibly more, feet long. Such are the iguanodon, the megalosaurus, and a number of others, with the names of which I will not trouble you. There are great diversities of structure among these great reptiles. Some of them resemble lizards in the proportions of their limbs, and have evidently walked on all fours, in such respect resembling the existing crocodile; but in others you can trace a series of modifications. The haunch bone and what we call the appendages, the hind limbs, underwent a series of modifications, until at length they completely assumed the character of a bird's hind limbs.



BIRD DINOSAUR CROCODILE

I here indicate [pointing to diagram] the hind limb of a crocodile, showing the bones of the hind limbs and of the pelvis. These are the haunch bones; these are the other pelvic bones. Then comes the division of the foot which we call the tarsus, the bones of which are separate and distinct. Then come the four toes, which exist only in the hind feet of the crocodile, and all which are separate and distinct. The foot is flat on the ground, so that the legs spread out and the weight of the body hangs clumsily between them.

Contrast this with what we find in the bird. The haunch-bone here is immensely elongated, and the joints of the back bone between the two haunch-bones are united together so as to form a solid support, upon which the weight of the body rests. Then the thigh bone becomes very short, and has a back ridge upon its outer articular surface. At the lower end the ridge fits in between the upper extremity of the small bone and the great bone—the fibula and tibia—and makes a kind of spring joint. Then this small bone of the leg is quite large above and becomes rudimentary below. It runs out into a style instead of being long and large, as it is in the case of the crocodile. Then when you come to the bones of the foot you find there are no separate bones such as you have here, but the end of the tibia, the large bone of the leg appears to end in a kind of pulley, and that by a single bone supported upon all three toes. Upon the extremity of that bone are attached these three toes. It is obvious that the contrast between the crocodile's leg on the one hand, and the bird's leg on the other, is very striking. That gap or interval is completely filled up when you study the character of the hinder extremities in those ancient reptiles which are called the Dinosauria. I have here such a pelvis and such a hind leg. This bone in the crocodile is represented in the Dinosaur by that long bone which approaches in form to the corresponding bone of the bird. The thigh bone of the Dinosaur lies parallel with the same bone as it does in the bird. In some of these birds all these four toes are turned forward, and they may be reduced to three; but these bones in the Dinosaur become so shaped that no motion is possible. Finding this modification in the limbs—in the Dinosaur the fore limbs become smaller and smaller—the suspicion naturally arises that the animals may have assumed the erect position. That view was entertained by Mantel, and was also demonstrated to be probable by your own distinguished anatomist, Leidy, but the discoveries of late years show that in some of these forms it was actually so; that you had reptiles then that used their hind legs exactly as birds now do.



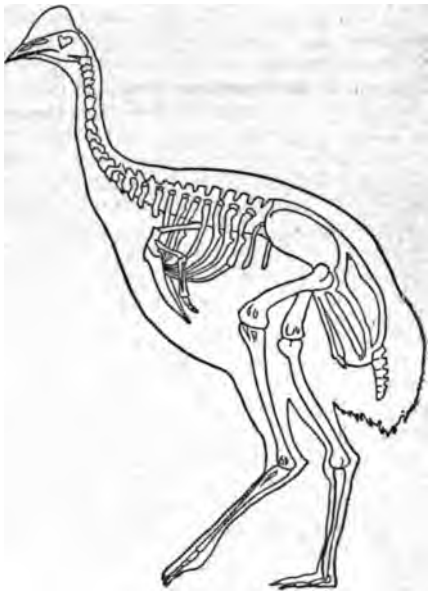
COMPSOGNATHUS LONGIPES *(Wagner)*

The diagram is a faithful and accurate representation of an existing fossil; except for this, that whereas in the existing fossil the bones are twisted about and out of place, I have put them here in the position that they must have had in nature, and now you see a creature with a long neck and bird-like head, with very small anterior extremities, with a slender termination, which is in almost all respects like that of a bird, and that animal must assuredly have walked about upon its hind legs, bird fashion. Add to this creature feathers, and the transition would be complete for the other characters. The possession of teeth would, as we see, not separate the creature from the class of birds we have had. We have had to stretch the class of birds to birds having teeth, and so far as the character of the skeleton goes we may fairly say that there needs here little more than the addition of feathers—and whether this creature had them we don't know—to convert it into a bird.

I have said that there can be no question, from their anatomical structure, that these animals walked upon their hind legs, and in fact there are to be found in the strata of England gigantic footsteps arranged in order like this of the *Brontozoum*, and which there can be no doubt were made by the *Dinosaur*, the remains of which were found in the same rock. And knowing that these reptiles that walked upon their hind legs and had the character generally of birds, did exist, it becomes a very important question whether those tracks in the Connecticut Valley to which I referred just now, and which formerly used to be unhesitatingly referred to a class of birds, may not all have been made either by true reptiles of this Dinosaurian type, or whether, if we could get hold of the skeleton which made these tracks, some of which are marvelously like bird's tracks, we should not come upon exactly that series of transitional forms by which in former days the reptile was connected with the bird.

I don't think, ladies and gentlemen, that I need insist upon the value of evidence of this kind. You will observe that although it does not prove that birds have originated from reptiles by the gradual modification of the ordinary reptile into a Dinosaurian form, and so into a bird, yet it does show that that process may possibly have taken place, and it does show that there existed in former times creatures which filled up one of the largest gaps in existing animate nature; and that was exactly the kind of evidence which I stated to you in starting we are bound to meet with in the rocks if the hypothesis of evolution be correct.

In my next lecture I will take up what I venture to call the demonstrative evidence of evolution.



CASSOWARY

[By way of comparison, a figure of the cassowary, a bird of the present era, was exhibited.]

EVIDENCES OF EVOLUTION—III.

PROF. HUXLEY'S CLOSING LECTURE IN NEW-YORK.

THE DEMONSTRATIVE EVIDENCE.

WHAT IS REQUIRED FOR A DEMONSTRATION—THE HORSE CONSIDERED FROM AN ANATOMICAL POINT OF VIEW—GRADUAL DEVELOPMENT OF HOOFS AND TEETH TRACED BACK IN PAST AGES—CHAIN OF PROOF OF DERIVATION—THREE-TOED AND FOUR-TOED HORSES—EVOLUTION AS THOROUGHLY PROVED AS THE COPERNICAN THEORY.

Notwithstanding a threatening sky, Chickering Hall was crowded on the evening of Sept. 22, to hear the final lecture of Prof. Huxley's brief series. Although strictly argumentative in form, the lecture kept the close attention of the audience throughout. Only two new diagrams were used, but Prof. Huxley made a few drawings on a blackboard. More frequent applause was elicited than at the previous lectures. The final sentences, in which he referred to his pleasant experiences during his visit and his preparation for departure at an early hour this morning, were delivered with much feeling, and were received with sympathy by the audience.

THE LECTURE.

LADIES AND GENTLEMEN: In my last lecture I had occasion to place before you evidence derived from fossil remains, which, as I stated, was perfectly consistent with the doctrine of evolution, was favorable to it, but could not be regarded as the highest kind of evidence before that sort of evidence that we call demonstrative.

I pointed out, in fact, that as we go back in time the great intervals which at present separate the larger divisions of animals become more or less completely obliterated by the appearance of intermediate forms, so that if we take the particular case of reptiles and birds, upon which I dwelt at length, we find in the mesozoic rocks animals which, if ranged in series, would so completely bridge over the interval between the reptile and the bird that it would be very hard to say where the reptile ends

and where the bird begins. Evidence so distinctly favorable as this of evolution is far weightier than that upon which men undertake to say that they believe many important propositions; but it is not the highest kind of evidence attained, for this reason, that, as it happens the intermediate forms to which I have referred do not occur in the exact order in which they ought to occur, if they really had formed steps in the progression from the reptile to the bird; that is to say, we find these forms in cotemporaneous deposits, whereas the requirements of the demonstrative evidence of evolution demand that we should find the series of gradations between one group of animals and another, in such order as they must have followed if they had constituted a succession of stages in time, of the development of the form at which they ultimately arrive. That is to say, the complete evidence of the evolution of the bird from the reptile—what I call the demonstrative evidence, because it is the highest form of this class of evidence—that evidence should be of this character, that in some ancient formation reptiles alone should be found; in some later formations birds should first be met with, and in the intermediate forms we should discover in regular succession forms which I pointed out to you which are intermediate between the reptile and the birds.

CHARACTERISTICS OF THE HORSE.

The proof of evolution cannot be complete until we have obtained evidence of this character, and that evidence has of late years been forthcoming in considerable and continually increasing quantity. Indeed it is somewhat surprising how large is the quantity of that evidence, and how satisfactory is its nature, if we consider that our obtaining such evidence depends upon the occurrence in that particular locality of an undisturbed series deposited through a long period of time, which requires the further condition that each of these deposits should be such that the animal remains imbedded in them are not much disturbed, and are imbedded in a state of great and perfect preservation. Evidence of this kind, as I have said, has of late years been accumulating largely, and in respect to all divisions of the animal kingdom. But I will select for my present purpose only one particular case, which is more adapted to the object I have in view, as it relates to the origin, to what we may call the pedigree, of one of our most familiar domestic animals—the horse. But I may say that in speaking of the origin of the horse I shall use that term in a general sense as equivalent to the technical term *Equus*, and meaning not what you ordinarily understand as such, but also asses and their modifications, zebras, &c. The horse is in many ways a most remarkable animal, inasmuch as it presents us with an example of one of the most perfect pieces of machinery in the animal kingdom. In fact, among mammals it cannot be said that there is any locomotive so perfectly adapted to its purposes, doing so much work with so small a quantity of fuel, as this animal—the horse. And as a necessary consequence of any sort of perfection, of mechanical perfection as of others, you find that the horse is a beautiful creature, one of the most beautiful of all land animals. Look at the perfect balance of its form and the rhythm and perfection of its action. The locomotive apparatus is, as you are aware, resident in its slender fore and hind limbs; they are flexible and elastic levers, capable of being moved by very powerful muscles; and in order to supply the engines which work these levers with the force which they expend, the horse is provided with a very perfect feeding apparatus, a very perfect digestive apparatus.

Without attempting to take you very far into the region of osteological detail, I must nevertheless—for this question depends upon the comparison of such details—trouble you with some points respecting the anatomical structure of the horse, and more especially with those which refer to the structure of its fore and hind limbs. But I shall only touch upon those points which are absolutely essential to the inquiry that we have at present put. Here [taking a leg bone of a horse in his hand] is the fore-leg of a horse. The bone which is cut across at this point is that which answers to the upper-arm bone in my arm, what you would call the humerus. This [referring to the bone] corresponds with my forearm. What we commonly term the knee of the horse is the wrist; it answers to the wrist in man. This part of the horse's leg answers to one of the human fingers, and the hoof which covers this extended joint answers to one of my nails.

Now, there are certain peculiarities about this structure bearing relation to further details of the different portions of the human arm to which I have referred. You observe that to all appearance [referring to the horse's leg] there is only one bone in the forearm. Nevertheless, at this end I can trace two separate portions; this part of the limb and the one I am now touching. But as I go further down it runs at the back part into the general bone, and I cease to be able to trace it beyond a certain point. This large bone is what is termed the radius, and answers to the bone I am touching in my arm, and this other portion of bone corresponds to what is called the ulna. To all appearance in the forearm of the horse the ulna is rudimentary and seems to be fused into one bone with the radius.

It looks thus as if the ulna, running off below, came to an end, and it very often happens in works on the anatomy of the horse that you find these facts are referred to, and a horse is said to have an imperfect ulna. But a careful examination shows you that the lower extremity of the ulna is not wanting in the horse. If you examine a very young horse's limb you will find that this portion of the bone I am now showing you is separated from the rest, and only unites as the animal becomes older, and this is, in point of fact, the lower extremity of the ulna: so that we may say that in the horse the ulna in the middle part becomes rudimentary and becomes united with the radius, and so early united

with the lower extremity that every distinct trace of separation has vanished.

THE FOOT OF THE HORSE CONSIDERED.

I need not trouble you with the structure of this portion that answers to the wrist, nor with a more full description of the singular peculiarities of the part, because we can do without them for the present, but I will go on to a consideration of the remarkable series of bones which terminates the fore limb. We have one continuous series in the middle line which terminates in the coffin bone of the horse upon which the weight of the fore part of the body is supported. This series answers to a finger of my hand, and there are good reasons—perfectly valid and convincing reasons, which I need not stay to trouble you with—which are demonstrative that this answers to the third finger of my hand enormously enlarged.

And it looks at first as if there was only this one finger in the horse's foot. But if I turn the skeleton round, I find on each side a bone shaped like a splint, broad at the upper and narrow at the lower end, one on each side. And those bones are obviously and plainly and can be readily shown to be the rudiments of the bone which I am now touching in my own hand—the metacarpal bones of the second and of the fourth finger—so that we may say that in the horse's fore limb the radius and ulna are fused together, that the middle part of the ulna is excessively narrow, and that the foot is reduced to the single middle finger, with rudiments of the two other fingers, one on each side of it. Those facts are represented in the diagram I now show you of the recent horse. Here is the fore limb [pointing to the diagram], with the metacarpal bones and the little splint bones, one on each side. It sometimes happens that by way of a monstrosity you may have an existing horse with one or other of these toes—that is, provided with its terminal joints.

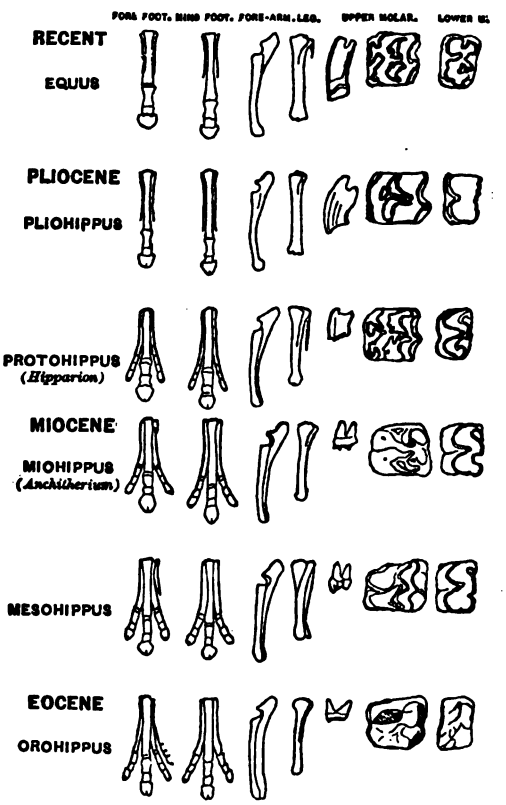
Let me now point out to you what are the characteristics of the hindlimb. This [pointing to the diagram] is the shin bone of the horse, and it appears at first to constitute the whole of the leg. But there is a little splint at this point [illustrating] which is the rudiment of the small bone of the leg—what is called the fibula—and then there is connected with this great bone a little nodule which represents the lower end of the fibula, in just the same way as that little nodule in the fore limb represents the lower end of the ulna. So that in the leg we have a modification of the same character as that which exists in the fore limb—the suppression of the greater part of the small part of the leg and the union of its lower end with the tibia. So, again, we find the same thing if we turn to the remainder of the leg. This [showing] is the heel of the horse, and here is the great median toe, answering to the third toe in our own foot, and here we have upon each side two little splint bones, just as in the fore limb, which represent the rudiments of the second and the fourth toes—rudiments, that is to say, of the metatarsal bones, the remaining bones having altogether vanished. Let me beg your attention to these peculiarities, because I shall have to refer to them by and by. The result of this modification is that the fore and hind limbs are converted into long, solid, springy, elastic levers, which are the great instruments of locomotion of the horse.

THE TEETH OF THE HORSE.

As might be expected, and as I have already said, the apparatus for providing this machine with the fuel which it requires is also of a very highly differentiated character. A horse has, or rather may have, 44 teeth, but it rarely happens that in our existing horses you find more than 40—for a reason which I will communicate directly—and in a mare it commonly happens that you find no more than 36, because the "tushes," or canine teeth of the mare, are rarely developed. Then there are some curious peculiarities about these teeth. As every one who has had to do with horses knows, the cutting teeth —the incisors—are six above and six below, and those incisors present what is called a "mark;" at least, that mark is usually present in horses up to a certain age. It is a sort of dark patch across the middle of the tooth. The presence of that dark patch arises from a great peculiarity in the structure of the horse's incisor tooth. It is in fact in sections shaped in this fashion [illustrating], considerably curved, and with a deep pit in the middle, and then a long fang. In the young foal this pit is very deep. As the animal feeds, this space becomes filled up with its fodder, that fodder becomes more or less carbonized, and then you have the dark mark, and the reason the dark mark serves as an indication of age, is that as the horse feeds, this is more and more worn down, until at last, in an aged horse, the tooth is worn beyond the bottom of the pit, and the mark disappears. Then, as I said, the male horse generally has canine teeth. We need not notice their structure particularly. In the female, these are rarely present. Following that, you may notice a very small and rudimentary tooth, but that is very often absent. It really represents the first tooth of the grinding series. Then there are usually to be found six great teeth, with exceedingly long crowns. The crowns, in fact, are so long that the teeth take a very long time to wear down, whence arises the possibility of the great age to which horses sometimes attain. This is shown in the side diagram. Then the pattern and structure of a horse's tooth are very curious. The crown of the horse's tooth presents a very complicated pattern: that is to say, supposing this to be one of the grinders of the left side [illustrating] above, there is a kind of wall like a double crescent. Then there are two other crescents, which fall in that direction, and these are complicated by folds, and all the spaces between these crescentic ridges are filled up by a kind of bony matter which is called cement. Consequently the surface of the tooth is composed of very uneven materials—of the hard mass of the tooth, which is called dentine, then a very much harder enamel, and a softer cement between, the practical effect of which is the same as the lamination of a millstone. In consequence of the lamination of the millstone

the ridges wear less swiftly than the intermediate substance, and consequently the surface always keeps rough and exerts a crushing effect upon the grain. The same is true of the horse's tooth, and consequently the grinding of the teeth one against the other, instead of flattening the surface of the teeth tends to keep them always irregular, and that has a very great influence upon the rapid mastication of the hard grain or the hay upon which the horse subsists.

I think that will suffice as a brief indication of some of the most important peculiarities and characteristics of the horse. If the hypothesis of evolution is true, what ought to happen when we investigate the history of this animal? We know that the mammalian type, as a whole—that mammalian animals—are characterized by the possession of a perfectly distinct radius and ulna, two separate and distinct movable bones. We know further that mammals in general possess five toes, often unequal, but still as completely developed as the five digits of my hand. We know further that the general type of mammal possesses in the leg, not only a complete tibia, but a complete fibula. The small bone of the leg is almost always smaller than the tibia. The small bone of the leg is as a general rule a perfectly complete, distinct, movable bone. Moreover, in the hind foot we find in animals in general five distinct toes, just as we do in the fore foot. Hence it follows that we have a differentiated animal like the horse, which has proceeded by way of evolution or gradual modification from a similar form possessing all the characteristics we find in mammals in general. If that be true, it follows that if there be anywhere preserved in the series of rocks a complete history of the horse, that is to say of the various stages through which he has passed, those stages ought gradually to lead us back to some sort of animal which possessed a radius, and an ulna, and distinct complete tibia and fibula, and in which there were five toes upon the fore limb, no less than upon the hind limb. Moreover, in the average general mammalian type, the higher mammalian, we find as a constant rule an approximation to the number of 44 complete teeth, of which six are cutting teeth, two are canine, and the others of which are grinders. In unmodified mammals we find the incisors have no pit, and that the grinding teeth as a rule increase in size from that which lies in front toward those which lie in the middle or at the hinder part of the series. Consequently, if the theory of evolution be correct, if that hypothesis of the origin of living things have a foundation, we ought to find in the series the forms which have preceded the horse, animals in which the mark upon the incisor gradually more and more disappears, animals in which the canine teeth are present in both sexes, and animals in which the teeth gradually lose the complications of their crowns and have a simpler and shorter crown, while at the same time they gradually increase in size from the anterior end of the series toward the posterior. Let us turn to the facts and see how they bear upon the requirements of this doctrine of evolution.



GENEALOGY OF THE HORSE.

In what is called here the pliocene formation, that which constitutes almost the uppermost division of the tertiary series, we find the remains of horses. We also find in Europe abundant remains of horses in the most superficial of all these formations—that is, the post-tertiary, which immediately lies above the pliocene. But these horses, which are abundant in the cave deposits and in the gravels of England and Europe—these horses, of which we know the anatomical structure to perfection, are in all essential respects like existing horses. And that is true of all the horses of the latter part of the pliocene epoch. But in the middle and earlier parts of the pliocene epoch, in deposits which belong to that age, and which occur in Germany and in Greece, to some extent in Britain, and in France, there we find animals which are like horses in all the essential particulars which I have just described, and the general character of which is so entirely like that of the horse that you may follow descriptions given in works upon the anatomy of the horse upon the skeletons of these animals. But they differ in some important particulars. There is a difference in the structure of the fore and hind limb, and that difference consists in this that the bones which are here represented by two

splints, imperfect below, are as long as the middle metacarpal bone, and that attached to the extremity of each is a small toe with its three joints of the same general character as the middle toe, only very much smaller, and so disposed that they could have had so very little importance that they must have been rather of the nature of the dew claws which are in the ruminant animals. This Hipparion, or European horse, in fact presents a foot similar to that which you see here represented, except that in the European Hipparion these smaller fingers are further back, and these lateral toes are of smaller proportional size.

But nevertheless we have here a horse in which the lateral toes, almost abortive in the existing horse, are fully developed. On careful investigation you find in these animals that also in the fore limb the ulna is very thin, yet is traceable down to the extremity. In the hind limb you find that the fibula is pretty much as in the horse itself. That is the kind of equine animal which you meet with in these older Pliocene formations, in which the modern horse is already or becomes entirely absent. So you see that the Hipparion is the form that immediately preceded the horse. Now let us go a step further back [illustrating] to these which are called the Miocene formations and which constitute the middle part of the deposits of the tertiary epoch. There you find in some parts of Europe—in Germany, Central Germany, in France, and in Greece—there you find equine animals which differ essentially from the modern horse: all that they resemble the horse is in the broad features of their organization. They differ still further in the characters of their fore and hind limbs, and present important features of difference in the teeth. The forms to which I now refer are what are known to constitute the genus *Anchitherium* [illustrating]. We have these three toes, and the middle toe is smaller in proportion, the lower toes are larger, and in fact large enough to rest upon the ground, and to have functional importance—not an animal with two dew claws, but an animal with three functional toes. And in the fore arm you find the ulna a very distinct bone, quite readily distinguishable in its whole length from the pradius, but still pretty closely united with it. In the hind limb you also meet with three functional toes. There is the same structure in the Hipparion's hind limb that there was in the case of the Anchitherium, and in the hind leg the fibula is longer. In some cases I have reason to think that it is complete; at any rate this lower end of it [illustrating] is quite distinctly recognizable as a separable though not exactly separated piece of bone. But the most curious change is that which is to be found in the character of the teeth. The teeth of the Anchitherium have in the first place, so far as the incisors are concerned, a more rudimentary pit—the pit is vastly smaller than in the horse. The canine teeth are present in both sexes. The molars are short; there is no cement, and the pattern is somewhat like this [drawing on the blackboard]. There are two crescents and two oblique ridges; while in the lower jaw you have the double crescent and a very slight complication at the extremity. It is quite obvious that this [illustrating from drawing] is a simpler form than that. By increasing the complexity of those teeth there we have the horse's teeth. These are all the forms with which we are acquainted respecting the past history of the horse in Europe. When I happened to occupy myself with this subject there was some difficulty in tracing them, but they left no doubt whatever in my mind that we had here a genuine record of the history of the evolution of the horse. You must understand that every one of these forms in time has undoubtedly become modified into various species and the like, and we cannot be absolutely certain that we have the exact line of modification, but it was perfectly obvious that we had here in succession, in time, three forms, fundamentally modified, in the horse type, of which the oldest came nearer to the general mammal—was far less modified than the Hipparion and what had taken place afterward. We saw that the animals which had existed afterward had undergone a reduction of their limbs and toes, a reduction of the lower bones of the hind leg, a more complete coalescence of the fibula with the tibia. The pattern of the molar teeth had become more complicated and the entire space had become filled with cement.

Consider what other alternative hypothesis lies open to you unless you admit this. In this succession of forms you have exactly that which the hypothesis of evolution demands. The history corresponds exactly with that you would construct *à priori* from the principles of evolution. An alternative hypothesis is hardly conceivable, but the only one that could be framed would be this, that the Anchitherium, the Hipparion, and the horse had been created separately and at separate epochs of time, and for that there could be no scientific evidence. And in the first place it is not pretended that there is the slightest evidence of any other kind that such successive creation has ever taken place. When I was investigating this subject all the collections in Europe were accessible to me, and they had led myself, and I may say, as I happen to know by correspondence with him, had also led that very eminent anatomist Prof. Lartet of Paris to the same conclusions. Indeed, the story is so plain that no one deserves any particular credit for drawing so obvious a conclusion. And since then, palæontological inquiry has not only given us greater and greater knowledge of the series of horse-like forms, but by and by enabled us to fill up the gaps in the series, and to extend that series further back in time.

FOSSIL HORSES IN AMERICA.

That knowledge has recently come to us, and assuredly from a most unexpected quarter. You are all aware that when this country was first discovered by Europeans there were found no traces of the existence of the horse in any part of the American co-

tinent. And, as is well known, the accounts of the earlier discoverers dwell upon the astonishment of the natives when they first became acquainted with that astounding phenomenon—a man seated upon a horse. Nevertheless, as soon as geology began to be pursued in this country, it was found that remains of horses—horses like our European horses—like the horses which exist at the present day—are to be found in abundance in the most superficial deposits in this country, just as they are in Europe. For some reason or other—no feasible suggestion on that subject, so far as I know, has been made—but for some reason or other the horse must have died out on this continent at some period preceding—how long we cannot say—the discovery of America by the Europeans. Of late years there have been discovered on this continent—in your Western territories—that marvelous thickness of tertiary deposits to which I referred the other evening, which gives us a thickness and a consecutive order of tertiary rocks admirably calculated for the preservation of organic remains, such as we had hitherto no conception of in Europe. They have yielded fossils in a state of preservation and in number perfectly unexampled. And with respect to the horse, the researches of Leidy and others have shown that numerous forms of the fossil horse have existed among these remains. But it is only recently that the very admirably contrived and most thoroughly and patiently worked-out investigations of Prof. Marsh have given us a just idea of the enormous wealth and scientific importance of these deposits. I have had the advantage of glancing over his collections at New-Haven, and I can truly and emphatically say that, so far as my knowledge extends, there is nothing in any way comparable to them for extent, or for the care with which the remains have been got together, or for their scientific importance to the series of fossils which he has brought together. [Applause.] That enormous collection has yielded evidence of the most striking character in regard to this question of the pedigree of the horse. And, indeed, the evidence which Prof. Marsh has collected tends to show that you have in America the true original seat of the equine type—the country in which the evidence of the primitive life and modification of the horse is far better preserved than in Europe; and Prof. Marsh's kindness has enabled me to put before you this diagram, every figure in which is an actual representation of a specimen which is preserved in New-Haven at this present time. The succession of forms which he has brought together shows, in the first place, the great care and patience to which I have referred. Secondly, there is this pliocene form of the horse (*Pliohippus*), the conformation of its limbs presents some very slight deviations from the ordinary horse, and with shorter crown of the grinding teeth. Then comes the form which represents the European Hipparion, which is the *Protohippus*, having three toes and the forearm and leg and teeth to which I have referred, and which is more valuable than the *European Hipparion* for this reason; it is devoid of some of the peculiarities of that form, peculiarities which tend to show that the European Hipparion is rather a side branch than one in the direct line of design. But next comes the form of *Miohippus* which corresponds pretty nearly with what I mentioned as the Anchitherium of Europe, but which has some interesting peculiarities. It presents three toes—one large one and two lateral ones—and the fourth toe, which answers to the little finger of the human hand, but there is only a rudiment of this, as in the lateral toe of the horse. This is, however, as far as European deposits have been enabled to carry us with any degree of certainty in the history of the horse. In this American tertiary, on the contrary, the series is continued evenly down to the bottom of the eocene, and these older rocks yield these remains. The miocene form termed *Mesohippus* has three toes in front and a large splint for the rudiment representing the little finger, and three toes behind. The radius and ulna are entire and the tibia and fibula distinct, and there are simply an chitheroid short crowned teeth.

But this is probably the most important discovery of all—the *Orohippus*—which comes from the oldest part of the eocene formation, and is the oldest one known. Here we have the four toes on the front limb complete, three toes on the hind limb complete, a well-developed ulna, a well-developed fibula, and the teeth of simple pattern. So you are able, thanks to these great researches, to show that, so far as present knowledge extends, the history of the horse type is exactly and precisely that which could have been predicted from a knowledge of the principles of evolution. And the knowledge we now possess justifies us completely in the anticipation that when the still lower eocene deposits and those which belong to the cretaceous epoch have yielded up their remains of equine animals, we shall find first an equine creature with four toes in front and a rudiment of the thumb. Then probably a rudiment of the fifth toe will be gradually supplied, until we come to the five-toed animals, in which most assuredly the whole series took its origin.

VALUE OF THIS EVIDENCE.

That is what I mean, ladies and gentlemen, by demonstrative evidence of evolution. An inductive hypothesis is said to be demonstrated when the facts are shown to be in entire accordance with it. If that is not scientific proof, there are no inductive conclusions which can be said to be scientific. And the doctrine of evolution at the present time rests upon exactly as secure a foundation as the Copernican theory of the motions of the heavenly bodies. Its basis is precisely of the same character—the coincidence of the observed facts with theoretical requirements. As I mentioned just now, the only way of escape, if it be a way of escape, from the conclusions which I have just indicated, is the supposition that all these different forms have been created separately at separate epochs of time, and I repeat, as I said before, that of such a hypothesis as this there neither is nor can be any scientific evidence, and assuredly, so far as I know, there is none which is

supported or pretends to be supported by evidence or authority of any other kind. I can but think that the time will come when such suggestions as these, such obvious attempts to escape the force of demonstration, will be put upon the same footing as the supposition by some writers, who are, I believe, not completely extinct at present, that fossils are not real existences, are no indications of the existence of the animals to which they seem to belong; but that they are either sports of nature or special creations, intended—as I heard suggested the other day—to test our faith. In fact, the whole evidence is in favor of evolution, and there is none against it. And I say that, although perfectly well aware of the seeming difficulties which have been adduced from what appears to the uninformed to be a scientific foundation. I meet constantly with the argument that this doctrine of evolution cannot be correct, because it requires the lapse of a period of time in which duration of life upon the earth is inconsistent with the conclusions arrived at by the astronomer and the physicist. I may venture to say that I am familiar with those conclusions, inasmuch as some years ago, when President of the Geological Society of London, I took the liberty of criticising them, and of showing in what respects, as it appeared to me, they lacked complete and thorough demonstration. But putting that point aside altogether, suppose that, as the astronomers, or some of them, and some physical philosophers tell us, it is impossible that life could have endured upon the earth for as long a period as is required by the doctrine of evolution—supposing that to be proved, what I want to know is, What is the the foundation for the statement that evolution does require so great a time? The biologist knows nothing whatever of the amount of time which may be required for the process of evolution. It is a matter of fact that those forms which I have described to you occur in the order which I have described to you in the tertiary formation. But I have not the slightest means of guessing whether it took a million of years, or ten millions, or a hundred millions of years, or a thousand millions of years to give rise to that series of changes. As a matter of fact the biologist has no means of arriving at any conclusion as to the amount of time which may be needed for a certain quantity of organic change. He takes his facts as to time from the geologist. The geologist, taking into consideration the rate at which deposits are formed and the rate at which denudation goes on upon the surface of the earth, arrives at certain conclusions more or less justifiable as to the time which is required for the deposit of a certain amount of rocks, and if he tells me that the tertiary formation required 500,000,000 years for its deposit, I suppose he has good ground for what he says, and I take that as the measure of the duration of the evolution of the horse from the orohippus up to its present condition, and if he is right, undoubtedly evolution is a very slow process and requires a great deal of time. But suppose now that the astronomer—or for instance, my friend Sir William Thompson—comes to me and tells me that my geological friend is quite wrong, and that he has capital evidence to show that life could not possibly have existed upon the surface of the earth 500,000,000 years ago, because the earth would have been too hot to allow of life. My reply is, "That is not my affair; settle that with the geologist, and when you settle that between yourselves I will agree with any conclusion." We take our time from the geologist, and it is monstrous that, having taken our time from the physical philosopher's clock, the physical philosopher should turn round upon us and say we are going too fast. What we desire to prove is, is it a fact that evolution took place? As to the amount of time it took for that, we are in the hands of the physicist and the astronomer, whose business it is to deal with those questions.

FAREWELL WORDS.

I think, ladies and gentlemen, that I have now arrived at the conclusion of the task which I set before myself when I undertook to deliver these lectures before you. My purpose and object has been, not to enable those of you who have not paid attention to these subjects before to leave this room in a condition qualified to decide upon the validity or the invalidity of the hypothesis of evolution, but to put before you the principles by which all such hypotheses must be judged; and furthermore, to make apparent to you the nature of the evidence and the sort of cogency which is to be expected and may be obtained from it. To this end I have not hesitated in regarding you as genuine students and persons desirous of knowing the truth. I have not hesitated to take you through arguments, and long chains of arguments, that I fear may have sometimes tried your patience, or to have inflicted upon you details which could not possibly be escaped, but which may well have been wearisome. But I shall rejoice—I shall consider I have done you the greatest service which it was in my power in such a way to do—if I have thus convinced you that this great question which we are discussing is not one to be discussed, dealt with—by rhetorical flourishes or by loose and superficial talk, but that it requires the keenest attention of the trained intellect and the patience of the most accurate observer. [Applause.]

I did not, when I commenced this series of lectures, think it necessary to preface them with a prologue, such as might be expected from a stranger and a foreigner; for during my brief stay in your country I have found it very hard to believe that a stranger could be possessed of so many friends, and almost harder to imagine that the foreigner could express himself in your language in such a way as to be so readily intelligible to all appearance; for, so far as I can judge, that most intelligent and perhaps I may add most singularly active and enterprising body of the press, your press reporters,

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